SLEEP CHARACTERISTICS IN BREASTFEEDING AND FORMULA-FEEDING MOTHERS

By

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ABSTRACT

The purpose of this study was to investigate the difference between sleep architecture, sleep characteristics and self-perception of sleep in breastfeeding and formula-feeding mothers 4 and 6 weeks post-partum. Forty-four subjects completed four nights of sleep data on the St.Mary's Hospital Sleep Questionnaire, three nights of wrist actigraphy, and one night of home polysomnography for recording sleep architecture characteristics. Baseline measures included demographics, previous sleep patterns and factors that could impact sleep. Results of an independent t-test indicated no significant differences in total sleep time. Multiple analysis of covariance comparing the sleep architecture characteristics of light sleep, deep sleep, and REM sleep while controlling for age, education level and nicotine use did not demonstrate any significant differences between groups. The variance of the measured sleep characteristic data was greater within the formula feeding mothers. There was a mean of 6.6 hours of sleep in both groups. In contrast to the study being replicated, sleep did not appear to be significantly different in this convenience sample. Mothers reported satisfaction with the quality of their sleep. Wrist actigraphy data reflected more sleep than either polysomnography or self-report. Further research is needed to determine the reasons for this difference.

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Chapter I

Background

Significance

Sleep is vital to survival and quality of life. Sleep deprivation is associated with adverse effects including those impacting health and relationships as well as emotional and intellectual functioning (Lee, 2003). Variation in sleep during the early postpartum period is present in varying degrees in most families and is compounded by the newness of parenting (Barnard, 1999). Wright, MacLeod and Cooper (1983) reported the two most pressing concerns of new parents are infant feeding and sleeping through the night.

Parental concern regarding sleep has not changed over the last quarter of a century as evidenced by So, Buckley, Adamson and Horne (2005) when they identified sleep problems as the topic of concern for which parents most often seek advice. In support of this finding Doan, Gardiner, Gay and Lee (2007) identified sleep deprivation as a primary concern among first time parents. According to Doan et al. (2007) postpartum sleep deprivation results in low energy, fatigue, irritability and delayed maternal recovery. This combination of symptoms could result in mothers feeling sad that they are not enjoying motherhood as well as decreased ability and energy for maternal-infant interaction (Mead-Bennett, 1990).

Contributing to postpartum sleep pattern disruptions is the biological programming of infants to wake following ninety-minute sleep cycles and the need to feed frequently to support their rapid growth. Yet according to some researchers the parental expectation is that infant sleep should mirror their own sleep patterns (Ball, 2003) and that parents' need for uninterrupted sleep and less frequent feeds can lead to abandonment of breastfeeding in hopes of alleviating sleep disruption (Doan et al., 2007; Marchand & Morrow, 1994). Despite these findings, the

relationship between *infant feeding method* and *sleep architecture and quality* is limited to one research study conducted by Blyton, Edwards and Sullivan in 2002.

Researchers, however, have examined infant feeding and sleep-related factors including where infants sleep, type of feeding (breast or formula), maternal educational level, and maternal fatigue perceptions. Elias, Nicolson, Bora and Johnston (1986) proposed that the mother's need for sleep without interruptions might lead to early weaning. Pinilla and Birch (1993) identified a positive relationship between the maternal need for uninterrupted sleep and the cessation of breastfeeding. Thomas (2000), when describing feeding method and its impact on sleep/wake patterns in preterm infants, postulated that the increased fussiness and subsequent decreased time available for positive interactions may be a factor in early cessation of breastfeeding. She found that although breastfed pre-term infants cried more than their formula-feeding counterparts, they did not differ in their sleep patterns. Wambach (1998) measured maternal perceptions of sleep quality and its relationship to breastfeeding over the first nine weeks postpartum and found no difference in fatigue levels of mothers who weaned and those who continued breastfeeding. However mothers with greater severity of breastfeeding problems and greater sleep disturbance reported more fatigue.

No studies in which sleep has been objectively measured as a variable impacting the duration of breastfeeding have been conducted. However, when exhausted, motivation, the cornerstone of duration of breastfeeding decreases (Heinig & Farley, 2001). Mothers often "give up" their plans and goals. Wright et al. (1983) reported that the discrepancy between the fantasies of what nursing will be like for mothers and the reality of night disruptions might explain the difference between intentions to breastfeed and the low rate of breastfeeding at 6 weeks postpartum. An earlier study (Wright, Fawcett, & Crow, 1980) demonstrated night

feedings were dropped earlier in formula-feeding babies. They suggested that breastfeeding mothers may see their formula-feeding counterparts able to sleep through the night at an earlier time, but they should be reassured that both are normal patterns.

There has been an assumption in our culture that "good" babies sleep better and longer, thus discounting the biological need for awakenings and feedings to support optimal health (McKenna & McDade, 2005). Alley and Rogers (1986) cited a number of studies that found no difference in the sleep patterns of breast and formula -fed infants, but described the societal belief that breastfed infants need more frequent feeds and will sleep less. Their own study, which used maternal reports of infant sleep, showed no significant differences between breast and formula -fed infants in terms of the number of night awakenings, but breastfed infants did average 20 minutes less sleep during the nighttime hours according to their study.

A commonly held, but not empirically confirmed belief that formula-feeding equates to increased infant sleep often influences the decision that new parents make regarding feeding. This notion is also perpetuated in the popular media. "Offer one bottle of formula and you will sleep much better," is reflective of popular culture's view about infant sleep and feeding. There is an assumption that feeding method is related to prolonged sleep. In the popular magazine *Baby Talk* (2003), the following statement about newborn sleep patterns is reflective of common beliefs, "A lot of this has to do with your baby's tummy: newborns aren't designed to go for longer than three hours without eating," (p. 28).

In a pamphlet from the National Sleep Foundation entitled *Women and Sleep,* the following passage reflects the common belief about infant feeding and sleep, "Once her baby is born, a mother's sleep is frequently interrupted, particularly if she is nursing. Mothers who nurse and those with babies that wake frequently during the night should try to nap when their babies

do…it is important for the mother's health, safety, performance and vitality." Fackler (2005) described on her internet site that babies fed with formula will usually sleep through the night by two months of age and feed less often compared with breast-fed babies who usually sleep through the night by 3-5 months of age. Perlstein (2008), on a physician-authored internet site, postulated that formula allows the entire family to be involved in care, including feedings, facilitating more rest for mothers, a needed commodity if the pregnancy or delivery were difficult.

To refute popular media's claims about infant feeding and sleep, Doan et al. (2007), explored in even more detail the impact of supplementation on total sleep time demonstrating that mothers who exclusively breastfeed actually obtained 40 to 45 minutes more sleep than those who offered formula supplementation. Blyton et al. (2002) reported less light sleep and an increase in deep sleep among lactating women when compared with a group of formula-feeding mothers and a group of same age nonpregnant and nonlactating women. Valuable though this research may be, the Blyton et al. study had the following weaknesses: 1) a small sample and unequal group sizes with twelve breastfeeding, seven formula-feeding and twelve nonpregnant nonlacting control women; 2) wide variation in the sample in length of time postpartum when data collection occurred (i.e. from 4 to 30 weeks postpartum), thus increasing the potential for extraneous variables (infant starting solids, mothers returning to work) to confound the results; and 3) no concurrent reports of sleep perception or description or measurement tools of the night before or after the home polysomnography were included. An enhanced study design that incorporates the basics of the Blyton et al. study with improved controls can provide much needed evidence regarding maternal sleep as it relates to infant-feeding method.

The American Academy of Pediatrics (2005), the Centers for Disease Control (CDC) and the Department of Health and Human Services' (HHS) all endorse breastfeeding as the optimal form of nutrition for human infants. The *Blueprint for Action on Breastfeeding* (HHS) and Ip et al. (2007) summarize the abundant research describing the health benefits of breastfeeding. Breastfeeding is the standard for health maintenance for mother and infant. Formula fed infants have more hospitalizations, respiratory tract infections, otitis media, diarrhea, pneumonia, urinary tract infections, necrotizing enterocolitis, and invasive bacterial infections. Mothers who can and do choose to breastfeed are afforded better health as well, showing a reduction in postpartum bleeding, reduced risk of ovarian cancer and breast cancer, Type II diabetes and osteoporosis (Rubinger, 2006). Also recognizing the benefits of breastfeeding, the Healthy People 2010 Objectives set the goal that at least 75% of women breastfeed when discharged from the birth setting, and at least 50% continue breastfeeding for 6 months. Therefore, further research to determine the relationship between infant-feeding method and sleep architecture should be pursued to further substantiate efforts to promote the continuation of breastfeeding beyond the early postpartum period to the recommended one year of life.

Purpose

Therefore, the aim of this systematic extension replication study is to add to the current body of knowledge regarding maternal postpartum sleep introduced in the Blyton et al. (2002) study that found less light sleep and increased deep sleep in lactating women when compared to their formula-feeding and control counterparts. The sample was heterogeneous on key variables of parity and infant age. Therefore the purpose of this study was to describe the differences in total sleep time and the sleep parameters of light sleep, deep sleep and REM sleep as well as

sleep interruptions in breastfeeding and formula-feeding mothers at four to six weeks postpartum in a sample of first time mothers.

Research Questions

The research questions for this study were:

1. What are the differences in sleep architecture characteristics including total sleep time, light sleep, deep sleep, and REM sleep and wake after sleep onset between breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?
2. What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?

Model of Impaired Sleep

Lee's conceptual model of impaired sleep will provide the theoretical guidance in terms of selection of variables for this study. Lee et al. (2004) described clearly the antecedents and consequences of the phenomenon of impaired sleep. In the model it is proposed that sleep deprivation or sleep disruption lead to sleep loss, which then leads to adverse health outcomes. The relationship of this model to the replication study will be more thoroughly discussed in Chapter II.

Terms

The following are terms of importance in this research. **Sleep** is defined by Carskadon and Dement (2005, p. 13) as "a reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment…a complex amalgam of physiologic and behavioral processes." Carskadon and Dement (2005) describe sleep in two alternating phases, non rapid eye movement (NREM) and rapid eye movement (REM) sleep, starting with NREM. **Non-REM sleep** consists of four stages: stages one and two are often referred to as light sleep or N1, N2, and stage

three and four are often called deep sleep or slow wave sleep (SWS), N3.4. Slow Wave Sleep is distinguished from light sleep by the increase in stimulus needed to arouse the sleeping person and the high voltage tracing on electroencephalogram (Carskadon & Dement, 2005). **REM** sleep is characterized by rapid eye movement, muscle atonia and dreams and occurs periodically throughout the sleep time, most pronounced in the second half of the night. (Carskadon & Dement, 2005). During a night's sleep, humans spend about 5% of the night awake, >5% in Stage 1 (N1) light sleep, 50-55% in Stage 2 (N2) light sleep, 17-24% in Stage 3,4 (N3) deep sleep and 20-25% in rapid-eye-movement (Lee, Zaffke, and McEnany, 2000).

Lee et al. (2004) described **sleep deprivation** as inadequate amount of sleep due to poor sleep hygiene, lack of consistent bedtime, care-giving, or developmental stages and **sleep disruption** as fragmentation of sleep related to medication, health issues, pregnancy, or sleep disorders. **Sleep loss** is described as getting less sleep than needed for optimal functioning, which is considered to be seven to eight hours of sleep by the National Sleep Foundation web site. **Total sleep time** is the total amount of sleep in a twenty-four hour period. **Night-time sleep** is defined in the literature as the sleep obtained from 9pm to 9 am (Goyal, Gay, & Lee, 2007; Lee &Lee, 2007). For the purposes of this study, night-time sleep was the time the patient stated they went to sleep at night until they woke up for the day.

Post-partum period is defined as the period following childbirth. For the purposes of this study weeks four, five or six will be utilized. **Breastfeeding or fully lactating** is defined for this study as a mother exclusively providing human milk to her baby through nursing or a combination of pumping and formula-feeding her human milk without providing human milk substitutes to the

baby for supplemental feeding. Supplementation could influence maternal and infant sleep patterns (Doan et al., 2007). **Formula-feeding** is defined as providing human milk substitutes (formula) exclusively to the baby from 14 days after birth without lactating through pumping or nursing the baby.

Assumptions and Limitations

Assumptions for this study include:

1. Post-partum women have changes in their sleep patterns.
2. Sleep loss is associated with infant feeding method.
3. The research process using home polysomnography, self-report tools and wrist actigraphy will not overly burden the new mother nor significantly change her sleep pattern.
4. There are demographic differences between breastfeeding and formula-feeding mothers.

Limitations include:

1. Convenience sampling with limitations imposed by the exclusion criteria may limit generalizability of the study finding to a broader childbearing population.

Significance of the research

Health care practitioners need empirical evidence to support the recommendations they provide to new families. Health care providers have frequent contact with families throughout the pregnancy and postpartum periods - ideal times to provide information on alternatives and choices as well as updated information about parenting. Correcting misinformation and offering suggestions for enhancing rest could help to sustain lactation and improve maternal and infant health. In a culture where formula-feeding is considered analogous to increased sleep, more evidence-based information on which parents can base their decisions is needed. This study will also serve as a basis for future intervention research to improve maternal sleep.

"Pregnancy and the postpartum period are times in a women's life when sleep patterns are greatly disturbed" (Wolfson & Lee, 2005). Wolfson and Lee report that the hormone prolactin, which is elevated with lactation, returns to a normal level by 24 hours after weaning. This difference in hormone levels between lactating and non-lactating postpartum women has been implicated, but not measured, to impact the architecture of sleep in one study only (Blyton et. al, 2002). Furthermore, at this time, this is the only study that describes sleep architecture in lactating and non-lactating postpartum women. If results from this replication study support their findings, then future research assessing prolactin and other hormone levels would be useful in contributing to possible mechanisms for the increased slow wave sleep (SWS).

The aim of this study was to describe the difference in sleep architecture, characteristics and self-reported descriptions and perceptions of sleep in breastfeeding and formula-feeding mothers between four and six weeks post-partum. Breastfeeding is often abandoned based on popular beliefs that have not been thoroughly researched such as "formula feeding means more sleep", or "breastfeeding means more sleep deprivation". This study will provide information for health care providers about any differences that might exist.

Summary

This chapter provides the foundation regarding the importance of sleep in the postpartum period as well as a description of research that deals with infant-feeding methods and sleep concerns of new mothers and families. Despite the popular belief that formula feeding is equated with increased infant and maternal sleep, only one study has documented differences in maternal sleep architecture based on infant-feeding method. The purpose of this replication study is to describe the sleep of mothers between four and six weeks postpartum and to describe the relationship between sleep and feeding method. Lee's Model of Impaired Sleep will guide the

selection of variables for the study and definition of terms. Terms, assumptions and limitations were provided to the reader and significance of the research was explored in this chapter.

Chapter II

Review of the Literature

Overview

The adjustments to parenthood are daunting and begin with the awareness of pregnancy. New mothers are faced with biopsychosocial changes. Maternal sleep is one such change and incorporates biological, psychological and sociological factors. Biologically, we need sleep to feel rested, to be alert and to function effectively. The birth itself often interrupts sleep, and the demand of an infant who needs frequent feedings exacerbates this change in early maternal sleep patterns.

At least eight hours of uninterrupted sleep is considered the average amount required for restfulness, and people function more effectively and generally feel better when they are rested (National Sleep Foundation, 2002). Yet, at four weeks postpartum mothers average 6.15 hours of night sleep and 7.53 hours in 24 hours - much of it interrupted. Infants average 14.65 hours of sleep in 24 hours, with less than half of that (6.15 hr) occurring during mother's usual sleep time (Quillin, 1997). Signal et al. (2007) reported a mean of 7.29 hours of sleep at six to seven weeks post-partum with a range of 4.37 - 9.72 hours for a group of first time mothers (N = 8) using wrist actigraphy and sleep logs to measure the sleep. Quillin and Glenn (2004) found that co-sleeping increased the overall amount of sleep for breastfeeding mothers, although breastfeeding mothers had more sleep periods in 24 hours. They also found breastfed newborns had less total sleep in 24 hours than their formula-fed counterparts. These investigators also found that approximately 14 hours is the average sleep for a newborn and called for more studies to look at the interaction between breastfeeding, fatigue, and sleep loss in postpartum women.

Some people tolerate little sleep; others need and crave at least eight hours to feel rested. If sleep deprivation has occurred, the mother may be unable to care for herself or her family and may feel unable to visit or socialize due to exhaustion (Williams et al., 1999). In a small descriptive study of fatigue in the first nine weeks postpartum among breastfeeding primiparae (N = 41), Wambach (1998) found no difference in fatigue levels of mothers who weaned and those who continued breastfeeding. However, mothers with breastfeeding problems and greater sleep disturbance reported more fatigue.

According to Young, Rabago, Zgierska, Austun, and Finn (2003), women with a tendency towards depression may find that sleep deprivation adds to the depressive symptoms. Women with postpartum mood disorders ranging from depression to the less common occurrence of psychosis or anyone with a history of mental health issues prior to pregnancy, may experience such conditions more during postpartum if they are sleep deprived (Mead-Bennett,1990; Lee, 1998; Goyal et al., 2007; Hunter, Rychnovsky & Yount, 2009).

Differentiating fatigue from depression can be a challenge. If fatigue is the only measure of sleep quality, it may not be an accurate assessment of maternal sleep. More objective measures are needed. The challenge of determining fatigue versus depression has been studied by Mead-Bennett (1990), Gardner (1991), and Milligan (1989). All three researchers called for measuring both fatigue and depression in order to determine the primary issue. Rychnovsky and Hunter (2009) and Dennis and Ross (2005) found that fatigue, sleep disturbances in mother and infant and depression are all interrelated. Ross, Murray and Steiner (2005) also addressed lack of clarity in research about the relationship between fatigue, depression “blues” and sleep. Ball (2003) described the knowledge that mothers and lactation consultants share: minimizing

disruption of sleep plays a positive role in the continuation of the breastfeeding relationship over the early months.

Wright et al. (1983) reported the two most pressing concerns of new parents relate to infant feeding and sleeping through the night. Sleep as a major parental concern has not changed over the last quarter of a century as evidenced by So et al. (2005) and Doan et al. (2007) when they identified sleep problems as the topic of concern for which parents most often seek advice. The body of research is growing regarding sleep during the postpartum period; however it is primarily limited to descriptions regarding sleep obtained by sleep diaries and wrist actigraphy. There is limited research looking at the quality or architecture of postpartum sleep, which is important to determining the impact on biopsychosocial outcomes.

This dissertation research was a systematic extension replication of the study done by Blyton et al. (2002) which reported increased deep sleep and decreased light sleep in breastfeeding mothers compared with formula-feeding mothers and a control group. The data obtained regarding sleep patterns of breast and formula-feeding mothers including total sleep time, light sleep, deep sleep, and REM sleep, as well as sleep interruptions, provides information that could be a starting point for clinicians and researchers exploring factors that influence breastfeeding duration and offering recommendations about sleep patterns in new mothers.

The review of the literature that follows will explore the relationship between feeding method, infant sleep environment, perceptions about sleep in the postpartum period and the relationship to maternal sleep. In addition, the model of impaired sleep (Lee, 2003), sleep measurement tools, and a critique of Blyton et al. (2002) are included.

The Relationship of Feeding to Sleep

"Give your baby cereal and he will sleep longer", or, "Offer one bottle of formula and you will sleep much better," are two comments reflective of popular culture's view about infant sleep and feeding. There is an assumption that feeding method is related to prolonged sleep. As described in Chapter I, common lay sources like parenting magazines and internet sites offer unsubstantiated information about the advantages of formula or early introduction of solids, as well as an expectation that breastfeeding will negatively impact sleep.

Inconsistencies also occur in the available research literature. Barnard (1999) definitively compared formula -fed babies, stating that they only average seven feedings, to breastfed babies who will eat up to fourteen times in twenty-four hours. She continues, "Breast-fed babies eat more often because the caloric and fat content of breast milk demands more frequent feedings to give babies the nutritional requirements and to bring satiation," (p.66). This position is in conflict with her statement asserting that self-regulation emerges from the newborn organizing his/her state of consciousness, his/her ability to maintain and change states, and the sensitivity of the caregiver in modulating the newborn's states and emotions. This modulation by caregiver in the expression of any newborn pattern from the environment must be reflected in research about infants and sleep.

The interrelationship of caregiver and environment influencing the infant's ability to organize states such as sleep is described in an experimental study by Pinilla and Birch (1993). The experimental group was instructed to offer a feeding between 10:00 pm and midnight and to try other interventions if the infant awakened such as re-swaddling, patting, diapering or walking the infant. If these alternative methods did not work, they were instructed to feed. They were also instructed to wait for the infant to fully awaken before intervening. In this study 100% of the

experimental group slept from midnight to 5:00 am, in contrast to 23% of the control group by 8 weeks of age. All babies were breastfed and consumed the same amount of breastmilk in 24 hours (as measured by pre and post-feeding weights). Although this was a small study with only 26 infants, it reinforced the impact that environment, rather than feeding method, can have on the pattern of infant sleep.

Many researchers have found no significant differences in sleep between breast and formula -fed babies. Parmelle, Schultz, Disbrow, and Litt (1961) examined total sleep by maternal report on the first 3 days of life. They studied 75 babies, of whom 43 were breastfed. They found no significant differences related to gender or feeding method. Alley and Rogers (1986) questioned the popular assumption that breastfed and formula -fed babies had different sleep patterns. They conducted a self-report study in mothers who used sleep diaries to report the sleep patterns of 79 breastfed and 53 formula-fed babies and found no significant difference in number of awakenings between the two groups. They did find that breast-fed babies had 20 minutes overall less sleep at 3 months of age and no difference at 5 months. A limitation of the study was that the definition of night was any sleep obtained from 6:00 pm to 5:59 am. It could be that mother's breastfeeding their babies tended to have a later time for sleep onset and morning awakening. They speculated that mothers who were breastfeeding provided a more rewarding environment for the baby to interact, thereby reducing sleep time.

Butte, Jensen, Moon, Glaze, and Frost (1992) found no differences between breastfed and formula -fed babies with respect to the number or duration of sleep cycles. Quillin (1997) reported that breastfed babies had more night awakening at 4 weeks of age, yet no difference in total 24-hour sleep than formula fed babies. Lee et al. (2000) found no significant differences in sleep patterns measured by home polysomnography at 1 month post-partum related to infant

feeding method. Quillin and Glenn (2004) showed no significant difference in the mother's 24-hour sleep pattern measured by self-report yet a significant difference in the infants with about 48 minutes less sleep in twenty-four hours for breastfeeding infants. Using wrist actigraphy and sleep diaries, Doan et al. (2007) actually found that parents of exclusively breastfed infants obtained more sleep by an average of 45 minutes than those who offered supplemental formula in the evening (6 P.M. to midnight) and 47 more minutes than those offering formula from midnight to 6 A.M.

Other investigators have found differences in sleep patterns of breastfed or formula -fed infants. Thomas (2000) found more crying in breastfed preterm infants (at 4 weeks corrected chronological age) in a 24-hour period and 30 more minutes of awake time in formula fed infants both day and night compared to their breastfed counterparts. It is interesting that Thomas reported this as an increase in wake time versus a decrease in sleep time. Thomas (2000) postulated that the increase in crying in breastfed babies time might account for mothers weaning, thereby reducing breastfeeding duration. Quillin and Glenn (2004) reported no difference in mother's sleep but more interruptions and less overall sleep in the infant's 24-hour pattern.

Stremler et al. (2007) conducted the first reported randomized control intervention study offering the experimental group strategies to enhance maternal sleep and education on normal infant sleep patterns and good sleep habits. The sleep intervention group (n =15) of mothers obtained a mean difference of 57 minutes and their infant 46 minutes more sleep than the control group and the mothers were less likely to report sleep as a problem. This study is currently being replicated with a sample size of 248 families.

Frequently new mothers report that napping while breastfeeding is the only way to get the sleep that they crave. New mothers also report that nursing makes them sleepy, perhaps related to the prolactin and oxytocin released with the milk ejection reflex. The concern with the strategy of lying down to nurse is the possibility of falling asleep with and overlaying the baby, and is not recommended by the American Academy of Pediatrics (AAP, 2005).

As evident in the review of infant feeding and sleeping there is conflicting information regarding the impact of feeding method on maternal and infant sleep. Other variables, such as SES, nighttime patterns or routines, or simply education on normal infant sleep patterns may have a stronger impact on total sleep time than feeding method. Parents are often under the impression, from the lay press, that if they change feeding methods from breastfeeding to formula-feeding the baby will sleep longer and they will consequently gain more sleep time.

The Relationship of Sleep Environment to Feeding

It has been suggested that bed sharing makes breastfeeding easier because the baby can nurse without disturbing the mother "too much" (UNICEF, 2003). However safety concerns have lead to recommendations that mothers not bed share in the following situations: if they are smokers, have consumed alcohol or taken other medications/ drugs that would cause sleepiness, or if they are unusually tired for fear of overlaying or smothering the baby (AAP, 2005). However the reality that exists for new parents, the desire to get much needed sleep and the desire to meet the needs of their baby, often cause parents to resort to bed sharing.

There are two positions on the issue of co-sleeping and the more common experience of reactive co-sleeping (when you bed-share out of desperation to increase your sleep), and health care providers fall in both camps, those for and those against. However, cultural background and history often drive the decisions made by any family. Thoman (2006) provided a review of the

environment and its relationship to sleep. She concluded that although the trend is for co-sleeping (bed-sharing), there is no scientific evidence to support the safety of the practice. In acknowledging this trend, she suggested that an attached crib to the maternal bed would address the safety concerns. Although she had no data on this, Thoman suggested that breastfeeding mothers are more likely to bed share with their infants. This is in contrast to the finding of Glenn and Quillin (2007) who found that formula-feeding mothers actually were more likely to bed share. Both authors address the complexity of sleep environments, feeding and patterns of parenting.

Reviewing the trends in bed-sharing, Willinger et al. (2003) found that overall 44.7% of infants spent at least some time in the parental bed at about 4 months of age. Routine bed-sharing rates doubled from 5.5% in 1993-1994 to 12.8% in 1999-2000. Demographics of bed-sharers would indicate that it is prevalent among Asian, Hispanic or African-American families, among younger mothers, and in low-income families.

Glenn and Quillin (2007) examined the differences in mother and fathers (N = 33) socioeconomic status on feeding methods, maternal sleep time and place of sleep. The authors identified mothers having the greatest impact on where baby sleeps, and that mothers of lower-socioeconomic status were more likely to co-sleep. Fathers who were of lower socioeconomic status tended to have formula -fed infants while high socioeconomic status fathers tended to have infants who breastfeed. Glenn and Quillin (2007) also reported that mothers who co-slept and breastfed obtained the most sleep.

A few studies have evaluated bed sharing by feeding method. Quillin and Glenn (2004) showed no significant difference in the mother's 24-hour sleep pattern yet mothers reported a significant difference of 48 minutes less sleep in twenty-four hours if breastfeeding their infants.

Ball (2003) studied subjects at 1 month (n = 253) and 3 months (n = 248) of age. Frequency of waking was significantly different by feeding method at both time periods, with more awakenings in the breastfeeding babies. A breastfed infant's awakenings were consistent between 1 and 3 months whereas formula-fed infants had fewer awakenings at 3 months. Interviews with mothers who weaned from the breast between the first and third month described the interruptions of breastfeeding on their sleep as the most influential factor for weaning. Ball (2003) reported a much higher incidence of bed sharing among the breastfeeding mothers. She recognized that mothers who persist in breastfeeding also may prefer bed sharing regardless of total sleep time or sleep issues.

Elias et al. (1986) studied sleep patterns and locations by comparing a "standard" group of 16 parents with a group of 26 La Leche League members. They found that breastfed infants who bed shared with their parents were the most likely to have short sleep bouts and more frequent feeds. They acknowledged that the La Leche League members were more likely to be comfortable with frequent nursing and bed sharing due to the support for bed-sharing by their organization. Elias et al. (1986) also reported an emerging trend toward bed sharing as more common in African American women than among Caucasians. They reported that this ethnic difference might be a factor in the outcome of past research regarding sleep patterns in newborns that were based on non-representative samples. They concluded by recommending that infant sleep/wake patterns should be revised based on new and updated research with more representative sampling.

Kennedy, Gardiner, Gay and Lee (2007) reported that over half of the 20 mothers interviewed about post-partum sleep reported bed-sharing as a strategy to enhance overall sleep. Glenn and Quillin (2007) reported that lower socioeconomic women who formula -feed also are

more likely to bed share. This is a group that also is more likely to smoke, a contraindication for bed sharing. Glenn and Quillin (2007) reported that 51% of the subjects bed share either all or part of the night. In addition, mothers who breastfed and bed shared obtained the most sleep. Since the mother influences the decision about place of sleep and method of feeding, it is important to recognize factors that influence both. In a study on support for breastfeeding, Crenshaw (2005) provided unsubstantiated information that bed sharing and breastfeeding happen concurrently adding that precautions must be made to ensure infant safety when co-sleeping.

Wailoo, Petersen, and Whitaker (1990) conducted a study of 87 infants 3-4 months of age in which they recorded body temperatures and found that breastfed babies and those who were over-wrapped were more likely to awaken their parents. However, only 17 of the 87 were breastfeeding at the time of the study, and the breastfed babies did not wake more often than formula-fed babies. Breastfed babies awoke sooner in the night, within 4 hours of sleep onset. These authors found that the early awakenings of the breastfeed babies (during what they termed the "unsocial" hours of the night) might have led to early weaning among the 44 mothers who were initially breastfeeding. They concluded that, "Perhaps a bottle at night-time might reduce this problem" (p.500) and further suggested that cooler rooms, with less wrapping and a bottle at bedtime, "Should allow parents a better night's sleep" (p. 501). The authors' assertions were not consistent with their findings, including the assumption that the earlier awakenings were more negative to the mothers and a formula bottle at bed-time was the solution.

McKenna et al. (1993) reviewed co-sleeping and its relationship to sleep development and Sudden Infant Death Syndrome (SIDS). An important point that McKenna made was that research to date was with solitary sleeping babies, not reflective of the biological norm and

evolutionary history of co-sleeping. As a highly dependent mammal, human infants are dependent on their mother (or caregiver) to influence the regulation of temperature, heart rate, breathing, sleep and arousal. McKenna et al. believed that the current climate of many sleep "problems" identified in our culture might be more related to a conflict between the infant's need for external regulation and psychosocial expectation of the society. McKenna concluded that the cultural aspects of each individual family must be considered in any observation regarding sleep.

Sadeh (McKenna et al., 1993) reinforced that parental perception of a sleep problem may be more psychosocially based than biologically based. Parents who co-sleep from the beginning perceive it as normal, as opposed to parents who reactively co-sleep. The later is an emotionally based decision made out of desperation for a longer night's sleep.

Thoman (McKenna et al., 1993) supported McKenna's hypothesis that co-sleeping might enhance regulation of the infant respiratory system. Thoman also raised an important question when discussing the uncritical use of ecological validity or naturalistic studies when there are known risks for certain populations (i.e. lower socioeconomic or smoking households that have higher rates of SIDS). How could we justifiably study co-sleeping in these "naturalistic" settings? The ethical dilemma that researchers must consider is the need for a naturalistic setting to provide accurate research versus potential risk to the infant if bed-sharing or another potentially unsafe situation exists.

McKenna, Mosko and Richard (1997) reported that 79% of cultures in the world share the same room with their infants and 44% the same sleeping surface. This assertion corresponds with numerous other studies, suggesting that in spite of the fact that we discourage co-sleeping, it is happening at high and possibly underreported rates. In this author's pilot study investigating

sleep of mothers from postpartum day 14-19, three out of 10 mothers reported co-sleeping and the other seven reported that the baby slept in the same room and occasionally in the same bed.

McKenna (2000) described cultural influences on infant sleep. He cited Lozoff's transactional approach which, "Acknowledges at the outset that 'normal' infant sleep development not only can vary within different cultural subgroups, but also from one infant to the next depending upon the interplay of intrinsic and extrinsic variables significant to each developing child," (p.207). McKenna (personal communication, 2005) suggested that the language of sleep interruptions, disruptions or deprivation begets the negative associations that we have about infants and sleep; night-time "interludes" would be a positive reference to the transition to a new reality of a baby who has a sleep pattern contrary to that of the mother.

Where a baby sleeps may be related to infant feeding methods as evidenced by the preceding section of the review of the literature. However, teasing out cultural, social and economic influences is difficult. Parents often are provided with conflicting information from health-care providers regarding the safety of bed-sharing. Out of desperation many parents reactively co-sleep. Given the potential influence of bed-sharing on sleep time, inquiring about where a baby sleeps is important in any evaluation of maternal sleep.

Infant Sleep

Infant sleep is a complex interaction of temperament, parent-infant interaction, and biological rhythms that are unique yet programmed in each individual. Neonatal sleep is expressed in short bursts divided almost equally between early onset of active sleep including rapid eye motion (REM) and body movement, followed by non-active sleep known as NREM or quiet sleep (QS) (Sleep Research Society, 2005). Thus the sequence and timing of infant sleep patterns would negatively impact an adult experience of "optimal sleep". A pattern of long bouts

of sleep might best meet the parental need for their uninterrupted sleep, but can be in conflict with the baby's need for frequent feeds and stimulation optimal for brain growth and development. At a recent American Academy of Sleep Medicine Conference, Roffwarg described new research about the importance of infant REM sleep in providing bilateral stimulation of the brain at the beginning of the sleep cycle. He hypothesized that NREM sleep at the beginning of the cycle could result in asymmetrical neuron development leading to unilateral motor and neuron functioning.

Barnard (1999) authored *Beginning Rhythms,* which discussed all aspects of biological rhythms as they apply to the newborn. Newborns have a disorganized circadian rhythm for the first few weeks of life with approximately equal sleep during the day and night until 2 months, when night sleep begins to dominate over day time sleep. After a few weeks of life infants are able to be awake or asleep for longer periods of time. It may be 6-9 months or more before sleeping through the night occurs. Core body temperature is not in synchrony with wake and sleep patterns until 1 month of age. Melatonin and cortisol, circadian driven hormones, are not endogenously produced until three months of age (Sleep Research Society, 2005). The rhythm of these "clocks" is dependent on brain maturation (biology) in conjunction with maternal-infant interaction (psycho/social) and environmental cues of light and dark (biological and psycho/social), thus producing the biopsychosocial framework identified by the Sleep Research Society (2005).

The rhythmic regularizing of this system is a function of maturation known to be stable from about 6 months of age until adolescence. Thomas (2007) described the achievement of circadian rhythm as a process in development which encompasses the regulation of sleep and wake patterns, the schedule of feedings, and interaction with parents and family life. This

process again mirrors the biopsychosocial adaptation to life. Entrainment, synchronizing to an external rhythm, occurs when a baby adjusts its internal rhythm with that of the environment (Thomas, 2007).

Supporting this experience of entrainment, Thoman, Holditch Davis and Denenberg (1987) found that infants showed significant individual differences in both sleep and wake states when alone and when they are with their mothers. Unique characteristics of infants and their patterns make the study of "normal" state regulation challenging for the researcher. Given that a mother might report only 12 hours of sleep for her baby one day and 16 hours the next, variance in the amount of sleep is not only between babies that are studied, but within the same infant.

Infant sleep architecture is still developing during the early months of life. It takes at least 6 months to establish sleep cycles more reflective of adult sleep patterns. Infant sleep has a normal range from 11 to 18 hours and becomes more consolidated with longer night-time sleep stretches by 3 to 6 months. Total sleep time and sleep wake patterns may also be related to infant temperament. Infant sleep patterns impact maternal sleep patterns and change over time. This change demands that the researcher narrow the data collection time in order to reduce variability caused by the impact of infant sleep on maternal sleep patterns.

Maternal and Infant Sleep in Context

McKenna (1994, p.188) quoted D.W. Winnicott, a child psychoanalyst, "There is no such thing as a baby, there is a baby and someone." The interactions and the relationship between parent and baby have a profound effect on the patterning of the infant, whether it be sleeping, feeding, or self-soothing. Maternal sleep cannot be studied in isolation, but must be explored within the biopsychosocial framework which includes infant sleep and the development of his or her evolving patterns.

Anders (1979) video-recorded infant sleep and noted that quiet awakenings at night by infants are not as frequently noted by parents as night noisy awakenings since they do not disrupt the parental sleep cycles. Forty-four percent of the two month olds, and 78% of the 9 month olds were considered to "sleep through the night" yet video recording revealed that only 15% at two months and 33% at 9 months actually slept without waking. Anders, Halpern and Hua (1992) reported on the sleep of 21 infants at 3 weeks, 3 months, and 8 months and found that sleep is both individual and relational. They found no difference related to method of feeding. What they found was that at 8 months the "problem" sleepers were more likely to be males who were put to bed asleep and who were not self-soothers (defined as use of pacifiers or finger sucking). Their videotape study showed individual infant differences in self-soothing related to sleeping through the night and relational differences in terms of being placed in bed awake or asleep and how often the parents checked on the infant.

Anders (1994) further explored the interaction between infant sleep and attachment. He described a transactional model of sleep that incorporates cultural, familial, and other environmental influences on infant sleep, acknowledging the extrinsic and intrinsic context of sleep which make the entrainment of sleep patterns or rhythms complex to study. One interesting finding was that mothers who tended to respond to their babies more consistently when the babies were awake also checked on their sleeping babies more frequently. Anders (1994) also addressed the interaction between sleep and feeding. He raised the possibility that patterns of inconsistent or difficult feeding might reflect difficult relationships between mother and baby which, consequently impact the sleep-wake pattern.

The challenge of understanding the maternal-infant relationship in the context of sleep was addressed at the American Academy of Sleep Medicine conference in Minneapolis, June

2007. Ramos (2007) from The University of California in Fresno described a parental interactive bedtime behavior scale which identified six factors that reflect the maternal-infant relationship. These factors include: awareness of signals, promptness, accurate interpretation of signals, availability, rhythmicity (routine versus a schedule) and maternal warm affect. In addition, Ramos (2003) made an important distinction between two types of co-sleeping, "planned" and "reactive." Reactive co-sleeping is sleeping with your baby to obtain more sleep.

The ability to self-soothe when first placed to sleep in bed awake or after night time awakening is one of the strongest predictors for healthy sleep-wake patterns in newborns (Burnham, Goodlin-Jones, Gaylor,& Anders, 2002). Breastfed infants were less likely to be self-soothers at 12 months of age when compared to those infants who had weaned. The authors concluded however, that the ability to self-soothe was individual and that infants select their own transitional object. They found that infants who were sleeping with parents at 12 months of age had all been sleeping in the parents' bed at 1 month of age. Infants who had longer quiet sleep (QS) bouts in early infancy were more likely to self-soothe at 12 months of age. In addition, babies who were in their own beds at 1 month and had parents who waited to respond to their awakenings had longer QS bouts.

Becker, Chang, Kameshima and Block (1991) looked at the impact of sleep patterns in infants of adolescents, and adult single mothers. They found no difference in the amount of total night sleep among breastfeeding mothers, but they did find that breastfeeding mothers were more prevalent in the older group with more support and stable home lives, thus supporting the proposition that psychosocial factors influence sleep beyond feeding method.

Hall, Saunders, Clauson, Carty and Janssen (2006) reviewed a number of techniques used to help extend infant sleep. Techniques included extinction, which encourages parents to ignore

the infant's cries altogether or gradually. They also suggested establishing better daytime sleep habits to improve nighttime sleep and development of routines for sleep time, feeding and bathing, as well as permanence of place of sleep. Hall et al. (2006) conducted a quasi-experimental study in which all groups received the same intervention. They found an increase in total sleep time and decrease in the number of sleep interruptions, but also a decrease in bed-sharing and breastfeeding. Due to the lack of a control group, it is unclear whether findings were a result of the intervention or were due to developmental changes.

Maternal Sleep

Adults typically fall asleep within 5 to 10 minutes after retiring and should average 7 to 8 hours in order to feel rested and have energy to meet the demands of the next day (Lee, 2003). Sleep changes are affected by a person's biology, psychology and social context, and sleep impairment can result in adverse health outcomes (Lee et al., 2004). Biologically, we need sleep to feel rested, to be alert, and to function effectively. The actual birth of an infant often interrupts sleep and the continuous demands of an infant who needs frequent feedings exacerbate changes in sleep patterns. According to Lee, "Pregnancy, childbirth and early motherhood physiologically and psychologically affect a woman's sleep," (1998, p.231). Furthermore, research supports the premise that sleep deprivation and sleep disruptions occur during these periods and that sleep loss can result in adverse health outcomes such as depressive symptoms and pain during early labor (Beebe & Lee, 2007; Goyal et al., 2007). Lee et al. (2000) studied sleep disturbances during pregnancy and postpartum and found that first-time mothers had the greatest sleep disturbance during the first month postpartum and at a greater rate than multiparous mothers. By three months postpartum there was no difference based on parity.

Quillin (1997) reported that at four weeks postpartum mothers average 6.15 hours of night sleep and 7.53 total hours of sleep in 24 hours - much of it interrupted. Lee and Lee (2007) compared sleep during the first post-partum week, between mothers who had cesarean (4.28 hours) and vaginal delivery (6.43 hours) finding overall less total night time sleep, by about 2 hours, and more interruptions in sleep among the cesarean birth mothers. However cesarean birth mothers slept about 10% of the daytime hours compared with 3% among vaginally delivering mothers.

There is a growing body of research on fatigue and impaired sleep in new mothers with respect to their role as caregivers (Doan et al., 2007; Glenn & Quillin, 2007; Goyal et al., 2007; Kennedy et al., 2007; Stremler et al. 2007; Quillin & Glenn, 2004). Doan et al. (2007) reported a lack of research that explored the relationship of sleep to supplementation with formula among breastfeeding mothers in the early postpartum months. In addition, the authors reviewed the conflicting research about the impact of feeding on sleeping, postulating that the lack of clear definitions of breast or formula-feeding as contributing to the sometimes opposing findings about the relationship between feeding method and sleeping. Doan et al. (2007) found in their study (n=133) that exclusively breastfeeding mothers obtained 40 to 45 more minutes of sleep per night.

Goyal et al. (2007) used data from an experimental study (N= 124) to look at the relationship between sleep and depressive symptoms. The factor most consistent at each time of measurement (last month of pregnancy and at 1, 2, and 3 month's post-partum), among subjects who scored 16 or greater on the CES-D questionnaire, was delayed sleep onset. The majority of the women in the study were breastfeeding, with 81% breastfeeding at time two, and declining to

64% breastfeeding at time four. Differences in the CES-D scores on sleep and feeding method were not described.

Kennedy et al. (2007) used interpretive hermeneutic qualitative methodology to explore a sub-group of participants (n = 20) from an experimental study they conducted. The participants' offered evidence of a new sleep consciousness that emerges after the birth of a baby. This non-purposive sampling resulted in interviews with primarily experimental subjects. The authors assured the reader that there was no difference between the 14 experimental participant interviews compared with the six from the control group, however few quotes were provided and none that compared the two groups. The authors concluded with advice for new parents regarding how to obtain optimal sleep. However, the conclusions were not clearly related to the findings.

Although it was a small study of maternal and infant sleep and feeding (N=30), Stremler et al. (2007) conducted the first reported randomized clinical trial to test strategies to enhance maternal and infant sleep with parental education about normal infant patterns and good sleep habits. Using wrist actigraphy, the sleep intervention group of 15 infants obtained a mean difference of 46 minutes more sleep and their mothers 57 minutes more than controls and parents were less likely to report sleep as a problem. In addition fatigue, depression, and state-trait anxiety were measured and no differences were found between groups. This low-tech cost-effective approach is currently being replicated in a larger sample (n=248) and holds promise for improving family sleep patterns.

A number of studies demonstrated that mothers are more quickly able to get into the deep restorative sleep after being awakened by the baby (Lee et al., 2000). Doan et al. (2007) found that mothers obtained an average 7.2 $\pm$ 1.3 hours of sleep if breastfeeding exclusively compared

to 6.4 $\pm$ 1.3 hours if the mothers supplemented their nursing babies with formula during the evening. However, objective differences in the sleep architecture (light, deep or REM sleep) of breastfeeding and formula-feeding mothers are limited to an initial study by Blyton et al.(2002) and one that compared breastfeeding mothers to non-post-partum or lactating women (Nishihara, Horiuchi, Eto, Uchida & Honda, 2004) .

Blyton et al. (2002) studied specific sleep architecture and found that deep sleep is maximized at the expense of light sleep in breastfeeding postpartum mothers. They compared breastfeeding mothers (n = 12) to formula-feeding mothers (n = 7) and a control group of women who were not pregnant, postpartum or lactating (n = 12). All of the subject groups were similar aged, from19-39 years with no statistically significant differences related to age or BMI between the groups. The mean infant ages were similar between groups but ranged from 4-30 weeks old in the breastfeeding group and 6-28 weeks old in the formula-feeding group. This range in infant age, although similar between groups covers the time periods in which infants establish more stable sleep patterns and mothers often begin their menses as well as introduce solid foods to their infants, potentially impacting milk supply and prolactin levels, thus introducing considerable variability on important confounding variables. Subjects also were given a questionnaire regarding their sleep length and quality, but the questionnaire was not identified and reliability and validity assessments were not described. The researchers did acknowledge that age of the infant and the amount of slow wave sleep (SWS) the mothers obtained were correlated but not to a level of significance.

The findings of Blyton et al. (2002) were supported by Nishihara et al. (2004) who compared a control group of non-pregnant women (n=12) to breastfeeding women (n= 12) at 9-13 weeks postpartum and identified prolactin as the possible factor influencing the increase they

found in slow wave sleep in the breastfeeding subjects. There was no comparison to formula-feeding subjects in the study, perhaps due to the very high rate of breastfeeding in Japan. Nishihara et al. (2004) questioned whether the increase in slow wave sleep was a result of the sleep deprivation caused by sleep disruption or if it was related to elevated prolactin levels during lactation. However they did not measure prolactin in this study.

Using two nights of home polysomnography and Rechtshaffen and Kales criteria for the staging of sleep Nishihara et al. (2004) determined postpartum women obtained about one hour less total sleep, which was a statistically significant difference.More importantly, it was determined that they obtained less light sleep (stage 2) and more deep sleep (stage 4), than the control women at a significant level. The researchers evaluated sleep architecture of the post-partum women who had interrupted versus non-interrupted sleep. Those with interruptions had less light sleep (stage 2) yet no significant differences were found in the amount of deep sleep between these groups leading the researchers to conclude prolactin was responsible for this difference.

In an earlier study, Nishihara and Horiuchi (1998) studied ten first time mothers during pregnancy and through six weeks postpartum using a seven lead home polysomnography. They found that the mothers (all breastfeeding) had delayed sleep onset in postpartum but no difference in other sleep architecture during the three postpartum times measured. Eight of the ten mothers were subjectively satisfied with their sleep. The authors concluded that the interruptions and disturbed sleep should not be referred to as sleep deprivation but instead "maternally acceptable sleep" (Nishihara & Horiuchi, 2004, p. 1052).

Many things impact sleep in new mothers including the method of delivery which may alter total sleep time. Postpartum depression may impact REM sleep onset latency as well as

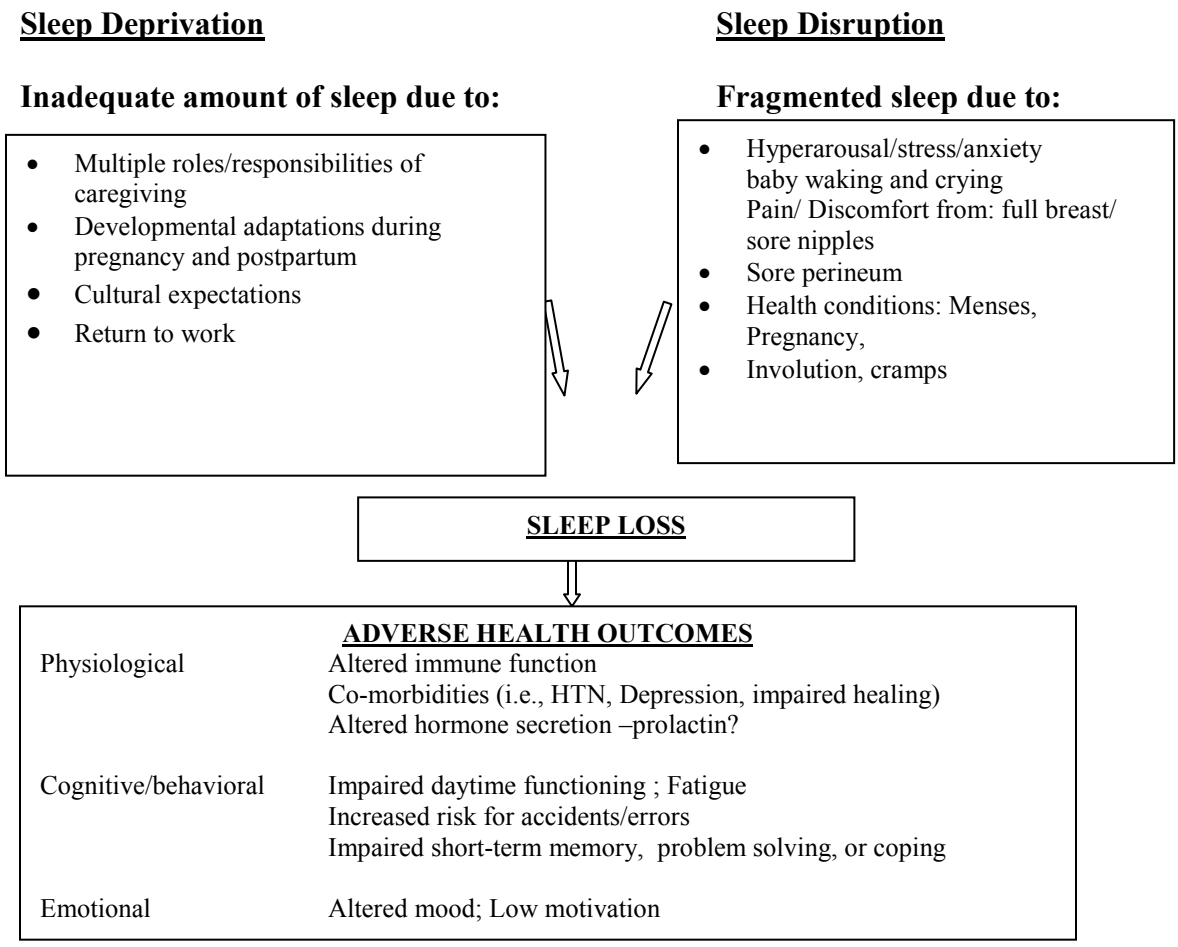
impacting poorly overall sleep quality (Lee, McEnany, & Zaffke, 2000). A wide range of total sleep time is found in postpartum women, with an average of 6-7 hours during the night with naps adding about an hour. Sleep patterns tend to stabilize by 3 months postpartum. Identified factors that may influence maternal sleep include, but are not limited to: method of feeding, supplementation with formula, care giving demands, co-sleeping and prolactin levels. How to enhance maternal sleep has been the subject of many studies because impaired sleep can influence the ability of a mother to function effectively.

Framework and Measurement Tools for the Study

Lee et al. (2004) offers a model of impaired sleep describing the antecedents-sleep deprivation and sleep disruptions, which lead to sleep loss and subsequent adverse health outcomes. Figure 1 is an adapted version, with the specific post-partum components of the model of impaired sleep identified.

This model is applicable to this study through the use of sleep deprivation and sleep disruptions which will be evaluated by the measurement of total sleep time and in particular the assessment of the sleep architecture which measures slow wave sleep, the deep restorative sleep that helps a person feel rested. Deprivation is related to the new role of caregiver which is influenced by the cultural expectation related to place of sleep and division of responsibilities between parents. Hormonal influences may impact the disruptions and return to sleep time as well as the cycling of full breasts and baby awakening for feeds. These factors could result in sleep loss, less than 7 hours of sleep, and subsequently adverse health outcomes identified in the model. Missing from this model is the subjective measure of how rested the subject feels after sleeping, therefore that variable will be measured. In addition because the review of the literature indicates an interaction between depression and sleep, depression will be assessed.

Figure 1. Lee's Model of Impaired Sleep



Adapted from Conceptual Model of Impaired Sleep - K. Lee PhD, RN (2003)

Sleep Measurement Tools

In order to assess sleep in this dissertation study, how to best measure sleep and describe the sleep architecture during the post-partum period is important to explore. There are two major classifications of sleep measures: subjective and objective.

Subjective Measures of Sleep

Subjective measures typically are self-reports of sleep parameters (e.g. sleep time and interruptions/awakenings and quality). Examples include the Sleep Activity Record (Barnard,

1999), Lee's General Sleep Disturbance Scale, the Pittsburg Sleep Quality Index (Buysse, et al., 1989), the Pittsburg Sleep Diary (Monk et al., 1994), and the St. Mary's Hospital Sleep Questionnaire (Ellis, Johns, Lancaster, Raptopoulos, & Priest, 1981). These self-report tools are easy to use and require no special equipment. For this study the mother's perception of her sleep quality will be evaluated with the St. Mary's Hospital sleep questionnaire each morning when she awakens. This information will provide insight into the relationship between amount of sleep obtained and maternal satisfaction or perception of sleep. The St. Mary's Hospital sleep questionnaire was designed to be used repeatedly and to assess the previous night of sleep. This questionnaire will provide a subjective measure of the sleep and will reflect the range of sleep that adults report to feel rested.

Objective Measures of Sleep

Objective measures include polysomnography and wrist actigraphy. Polysomnography, which simultaneously records EEG, EOG, and EMG, is considered the "gold standard" for measuring sleep and diagnosing sleep disorders. However, polysomnography usually requires staying overnight in a sleep laboratory to control for environmental light and noise, and thus is not practical for studying poor sleep in the home setting. Furthermore, for new mothers, staying overnight in a sleep laboratory may be a great burden. Home polysomnography has been used in a limited number of studies on maternal sleep.

Blyton et al. (2002) compared sleep architecture using a five channel home portable polysomnography machine for only one night. They only used one night of assessment reasoning that the home setting did not require the acclimation to a new environment for sleep that would be necessary if the assessment was done in a laboratory setting. They did question the participant about the previous night of sleep to ascertain if sleep deprivation was an issue. Consistent with

other studies, Rechtshaffen and Kales criteria were used to describe the sleep staging. It is a process of identifying wakefulness, NREM and REM sleep (Carskadon & Rechtschaffen, 2005). This staging technique will be further described in the methods section.

Wrist actigraphy is an alternative measure that has been in used in sleep research for over 20 years. It is the "continuous recording of body (often wrist) movement by means of a body-worn device that detects movement (usually acceleration) and stores the information for days, weeks, or months, along with the time it was measured" (Pollack et al., 2001, p. 957). Actigraphy is useful for recording rhythms, particularly circadian rhythms. It is a useful measure when polysomnography is not practical, and thus for new mothers is an appropriate objective measure of sleep and activity patterns.

Wrist actigraphy is less expensive to use than polysomnography, provides data for 24-hour cycles, and has been shown to be more reliable than sleep logs in clinical research due to issues of recall of awakenings and periods of sleep (Ancoli- Israel et al., 2003). Ancoli-Israel et al (2003) concluded that in general actigraphy devices are reliable, stressing that the actigraph needs to be worn on the same wrist throughout the observation. They found a strong correlation between actigraphy and polysomnography when looking at sleep wake cycles supporting the validity of actigraphy. The large majority of studies evaluating maternal postpartum sleep have used wrist actigraphy (Beebe & Lee, 2007; Doan et al., 2007; Gay et al., 2004; Kang, Matsumoto, Shinkoda, Mishima & Seo, 2002; Lee & Lee, 2007; Nishihara & Horiuchi, 1998; Signal et al., 2007; Stremler et al. 2006). Fewer have used home polysomnography, due to the expense and need for a certified sleep technologist to score the data (Lee et al., 2000; Nishihara & Horiuchi, 1998).

Simultaneous Use of Subjective and Objective Measures of Sleep

Subjective and objective measures also can be used together and limitations of one type of measure may be off-set by strengths of the other type. For example, sleep logs provide details about the disruptions that occur, but may not always reflect the actual sleep time (Ancoli-Israel et al, 2003). Furthermore, self-reporting tools have been shown to have a weak correlation to both polysomnography and actigraphy (Ancoli-Israel et al., 2003). Given that new mothers experience repeated sleep interruptions for infant feedings and care, the subjective measure is valuable for documentation of such events, but the objective measure is valuable for more accurate timing. Convenience, comfort, time efficiency and ability to record a number of days of data also support the use of wrist actigraphy in assessing maternal sleep when combined with the confirmatory data that a sleep log or diary provides (Signal et al., 2007). Sleep logs, diaries or subjective questionnaires on the quality of sleep are commonly used in conjunction with objective measures when examining maternal sleep (Beebe & Lee, 2007; Blyton et al., 2002; Goyal et al., 2007; Kang et al., 2002; Lee & Lee, 2007; Shinkoda, Matsumoto & Park, 1999; Signal et al., 2007; Stremler et al., 2006).

Pilot Study

Reliable and valid measures of sleep in breast and formula-feeding mothers are important for building the knowledge base. However, ease of use, burden to the subject, and reliability and validity testing in the study of sleep in new mothers is limited. Therefore, in a prospective descriptive pilot study, the usability and comparability of two measures of maternal sleep, the wrist actigraphy and Sleep Activity Record were evaluated (Rosen, 2007). Ten English speaking first time mothers agreed to participate. Paired t-tests, line graphs, intraclass correlations and

repeated measures ANOVA compared the tools on total sleep time and sleep interruptions within and between subjects.

Subjects reported the instructions were clear, the wrist actigraphy was comfortable, and both tools were easy to use. The main effects for the sleep measures and time were not significant indicating no differences between the measures and consistency across the five nights. However, the between subject effect was significant ($F = 540.83$, $p < .000$), reflecting the wide range of total sleep hours or sample variability among the subjects.

Across the five nights, sleep interruptions ranged from zero to eight as measured by the sleep activity record and three to nine times by wrist actigraphy. The assumption of sphericity for the repeated measures ANOVA using Mauchly's test was plausible ($p = .33$). The overall test for within subject differences in means of sleep interruptions between tools was significant ($F = 20.46$, df1=1, df2, $p = .001$). The pairwise comparison ($p = .001$) indicated fewer interruptions using the sleep activity record ($M = 2.92$, $SE = .447$) in comparison to the wrist actigraphy ($M = 5.26$, $SE = .327$). There was no main effect of time however, indicating consistency within measures across time. The between subject effect was significant ($F = 193.29$, $p < .001$) indicating variation between subjects' reported interruptions. Stability of the measures within subjects was further confirmed. The ICC values for total sleep time over the five nights with the wrist actigraphy was .87 ($p < .01$) and for sleep activity record was ICC = .46 ($p = .09$). For sleep interruptions using the wrist actigraphy, the ICC was .62 ($p = .02$) and for sleep activity record the ICC was .89 ($p < .01$).

There were no significant differences found in total sleep time for the 10 subjects and 5 nights between the tools, however sleep interruptions were significantly different ($t (9) = -4.52$, $p < 01$). These results are consistent with the single night results above. Therefore, the two tools

were comparable over a five-night period for total sleep time but **not** for sleep interruptions. There was wide variance in sleep patterns between mothers from 5-11.75 hours in a 24 hour periods. Subjects tended to under-report sleep interruptions and over-report total sleep time. The conclusion was that wrist actigraphy and sleep activity records are appropriate for use in new mothers. The Sleep Activity Record and Wrist Actigraphy appear to be reliable (consistent) measures of sleep in new mothers. The measures are comparable in measuring sleep, but less so in measuring interruptions.

Rationale for Replication Study

Blyton, Sullivan, and Edwards (2002) provided the only study using polysomnography to compare breastfeeding, formula-feeding and a control group of non-postpartum women. A small sample was used and other features as described previously weakened the study design. Therefore, a replication study could add support to their findings or suggest further study. A systematic extension replication study, sometimes known as a constructive replication (Polit & Beck, 2004) was conducted. This method replicates the study to the extent that it tests the conclusions that the first study put forth. The changes in this study will be a narrower post-partum time frame with a more homogeneous sample of primiparas, more clarity about the questionnaire or subjective measure of sleep used, and the addition of wrist actigraphy assessment of the sleep surrounding the night of home polysomnography to observe if the nights of sleep are comparable.

Summary

The study of maternal postpartum sleep requires the researcher to be attentive to the plethora of factors impacting sleep during this period. This chapter provided a review of the literature regarding maternal and infant sleep, and the relationship of both to feeding method and

place of sleep. A critique and discussion of the need to replicate the Blyton et al. (2002) was included. In addition this chapter included a description of Lee's model of Impaired Sleep and an overview of sleep measurement.

Chapter III

Methodology

This chapter includes several sections: a description of the study design, study setting and sample, the criteria for participant inclusion in the study, the participant recruitment and data collection procedures, the instruments used to collect data, reliability and validity plans, and the data analysis for each research question. Ethical considerations in the study are also discussed.

Design

The study was a descriptive comparative prospective study of the sleep architecture of twenty-two breastfeeding and twenty-two formula-feeding mothers for three nights between the fourth and sixth weeks postpartum. The total amount of sleep time (TST), total number of sleep interruptions and the comparison of breastfeeding and formula-feeding women on selected sleep parameters as measured by wrist actigraphy and home polysomnography were the focus of this study. A measurement of one night of sleep using home polysomnography provided measures of TST, light sleep (N1,N2), deep sleep (N3,N4), and REM sleep as well as number of arousals. The research questions for this study were:

1. What are the differences in sleep architecture characteristics including total sleep time, light sleep, deep sleep, REM sleep and wake after sleep onset between breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?
2. What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?

The framework that guided this study was Lee's (2004) model of impaired sleep, which describes the impact of sleep disruptions and sleep deprivation resulting in sleep loss and

subsequently impacting physical and emotional health. Much evidence exists supporting Lee's model regarding the impact of maternal sleep impairment during postpartum (Beebe & Lee, 2007; Doan et al., 2007; Glenn & Quillin, 2007; Goyal et al., 2007; Kennedy et al., 2007; Lee and Lee, 2007; Lee et al., 2000; Stremler et al.,2007; Quillan & Glenn, 1997, 2004). In particular for this study, the model highlights sleep disruption and impairment resulting in sleep loss, an identified concern of new parents (So et al., 2005).

To add to the body of knowledge regarding sleep in the postpartum period a systematic replication study of Blyton et al. (2002) was conducted. A systematic extension replication involves testing the implications of the previous study without precise duplication of the methods (Polit & Beck, 2004). Blyton et al. (2002) compared breastfeeding participants, formula-feeding participants and a comparable group of non pregnant/ non-lactating menstrual cycling women regarding the differences in sleep measures of light sleep, deep sleep and REM sleep. This study differed from Blyton et al. by having larger groups of breastfeeding and formula-feeding participants, and by eliminating the non-pregnant control group of women (those who are not impacted by care of an infant and postpartum recovery). Furthermore, the data collection time frame was 4-6 weeks postpartum, as opposed to 4-30 weeks postpartum, thereby narrowing the data collection period by twenty-one weeks, and reducing potential extraneous variables such as different maternal hormone levels or infant or maternal sleep patterns. In addition participants were limited to first time mothers who were not taking medications that impacted sleep. Three nights of wrist actigraphy was also obtained, the first night to acclimate the participants to this sleep study and the second night to validate the findings of home polysomnography and a final night after the polysomnography study was completed.

Study Setting

Multiple sites that provided maternity care services in a mid-western city, including local health departments maternal and infant programs; two Midwest hospitals; and a birthing center were used as recruitment sites, letters of support were obtained and submitted with the IRB proposal (See listing of letters of support obtained, Appendix A). By using all of these settings, the possibility of obtaining a socio-economically diverse group of new mothers was strengthened. The pilot study for this research was conducted in this same community and achieved an ethnically diverse sample (Rosen, 2007).

Hospital A is a community based 400-bed tertiary care level hospital that has approximately 200 births a month. Hospital B, privately owned, has approximately 80 births a month, and the birthing center, privately owned, has approximately 20 births a month.

Inclusion and Exclusion Sampling Criteria

Inclusion criteria included maternal participant age of 20-37 years. A lower age limit of 20 was selected to assure that adolescent sleep patterns would not confound the findings. The upper age limit was to reduce the changes in sleep characteristics that come with age. Lee (as cited in Carrieri-Kohlman, Lindsey, & West, 2004) described impaired sleep and developmental stages, stating that adolescents are known to experience delayed sleep phase syndrome due to their late bedtime and difficulty rising in the morning. The participants were English speaking, able to read and write. In addition they had to be willing to wear wrist actigraphy, complete a sleep questionnaire for 3 nights, and also be willing to be connected to home polysomnography for one night on night two of the study. If a polysomnographic reading was unable to be obtained or if a polysomnography lead came detached during the study, the participant was asked to participate in one more night of data collection.

Inclusion was limited to first time mothers with a singleton pregnancy to reduce variability in the sample due to differences in demands among mothers of multiples and those with other young children. In addition, only participants having a vaginal delivery or those who had a cesarean delivery, but had not taken medication for pain in the last two weeks, were included to reduce the potential confounding of any effects pain medications have on sleep architecture. Inclusion also was limited to mothers who were living with another adult, married or otherwise partnered and who had no other children living in the household demanding childcare responsibility to reduce the variability in home life demands within the sample. Participants were without any history of disclosed or medically diagnosed sleep disorders.

Inclusion criteria with respect to the participants' infant characteristics included a normal newborn assessment with a gestational age of 37 weeks or older as determined by gestational age assessment. These criteria were included because sleep adjustments, due to these conditions could be made during the postpartum period in infant care and feeding. Infants had usual care in the newborn nursery, without admission to the intensive care unit. The infants were average for gestational age at birth and sustained normal weight gain of at least twelve ounces over birth weight at the time of the study data collection onset. This weight parameter was based on minimal weight gain expected in a newborn by one month of age (Lawrence, 2005). All infants had gained at least 12 ounces above birth weight by the beginning of the study activities so none were excluded, thereby reducing the possibility that sleep was impacted by the infant's demand or lack of demand for feeding.

Exclusion criteria included any mother on antidepressant or pain medication as these drugs have been shown to impact sleep architecture (Schweitzer, 2005). Women with a recent history of depression or mood disorder were excluded. Eleven participants had past histories of

situational depression, but they had been without medication for at least 2 years and scored 10 or less on the Edinburgh Postpartum Depression Scale during screening prior to beginning data collection. Exclusion criteria also included participants who planned to or had returned to work prior to 6 weeks postpartum because work schedules could impact or challenge sleep. Finally, women with known sleep disorders were excluded from the sample.

Sample

Forty-seven participants were consented for the study. The analyzable sample consisted of 44 participants and included 22 breastfeeding and 22 formula feeding paticipants. Sample size was determined by a power analysis along with careful determination of the inclusion and exclusion criteria that reduce the potential variables that could confound the results. Power for a research study is based on a combination of sample size, effect size and level of significance. In addition, controlling for extraneous variables that could impact the outcome was important.

To determine power, findings from previous studies by Blyton et al. (2002) and Nishihara et al. (2004) were used. Blyton et al. found a difference in slow wave sleep mean percentage of 15 +/- 6% for the formula-feeding mothers compared with 43 +/- 7% in the breastfeeding mothers, resulting in an effect size of 4 (determined by subtracting 15 from 43 and dividing by the standard deviation of 6.5). In Nishihara et al. (2004), breastfeeding primiparae at 9-13 weeks postpartum had 25.6% +/- 5.5% SWS compared to nonpregnant controls who had 19.8+/- 6.7% SWS. This effect size is .86 (25.6-19.8, divided by SD of breastfeeding group =1.05; divided by SD of controls). If it is calculated by the SD of the non-pregnant controls it equals 0.97. This is a large, clinically meaningful, effect size related to slow wave sleep. Therefore, this power analysis indicated that with a large effect size between .86 and 4, the power would be greater than .80, at a.05 level of significance for a sample of 20 participants per group.

Although Blyton et al. (2002) did not report power in their study, a power calculation by the investigator yielded a very large effect of 4, despite a small sample size. The breastfeeding mothers obtained over one and a half hours more slow wave sleep than the control subjects or formula-feeding mothers at the expense of their light sleep. According to Lee et al. (2000), 20% of each night's sleep is typically spent in deep sleep. Given this information, a person who sleeps for 8 hours spends about 1.6 hours in deep sleep. The breastfeeding subjects in Blyton et al. (2002) spent a mean of 3.03 hours in deep sleep and the formula-feeding subjects spent 1.05 hours in deep sleep and the controls 1.43 hours in deep sleep. The effect of breastfeeding on sleep appeared to be large in this study. Total sleep time was not significantly different between groups with only one minute difference between breastfeeding and formula-feeding mothers and 25 more minutes of total sleep in the control group.

In designing this systematic extension replication study considerations beyond the power calculations were made. This included equalizing group sizes and potential external sources of error such as high variability of infant age. In addition, all participants in the current study were first time mothers thus decreasing the potential impact of other children on sleep patterns. The mothers in this study had also not returned to work outside the home.

In the pilot study (Rosen, 2007) there was a 41% pre-consent attrition rate (i.e. potential participants who expressed interest and then declined at follow-up). This rate of attrition guided the investigator to recruit approximately 60 participants, 30 for each group in order to obtain at least 20 participants for each group. There was no post-consent attrition in the pilot study (Rosen, 2007), i.e. all participants who consented completed the study. The goal for the current study was to enroll the 60 participants and collect data in 5 months. This averaged 16-18 recruits a month in a community in which approximately 300 babies are born each month. Of that total,

one-third are first time mothers, reducing the pool to 100. Approximately 5% are pre-term and 10% are teens or over 37, reducing the available pool to 85 potential subjects a month.

The goal of 60 recruits in 5 months was assumed to be reasonable, however enrollment of exclusive formula-feeding mothers was challenging due to the high rate of breastfeeding initiation (90%) among first time mothers between the ages of 20 and 37. It took 48 weeks to recruit and enroll participants.

Recruitment and Enrollment Procedures

Prior to recruitment activities approval was obtained from the Kansas University Medical Center Human Subjects Committee and the IRB's at the local hospitals where recruitment occurred. Expectant or newly delivered women in the midwest city were provided information about the study through IRB approved posters in high traffic areas of the hospitals or clinics, in classes for expectant and new parents, and at public health department Women Infant and Children's (WIC) offices. Letters explaining the study and inclusion criteria were disseminated by staff at the participating facilities. These staff attended an information session about the study prior to recruitment activity.

In the hospital/birthing center settings, first time mothers who matched the inclusion criteria were approached by a trained recruiter after delivery to see if they were interested in more study information. In the hospitals during discharge instructions or during the follow up visit at the clinics of hospitals A or B, a nurse trained in recruitment showed the study poster (Appendix B) to mothers who met the sampling criteria. At the health department during their WIC appointment the WIC staff pointed out the study poster to determine interest. If they expressed interest in participating, an information letter was presented (Appendix C). If after

reading this letter they had continued interest, potential participants provided contact information and signed a permission form to allow the investigator to contact them.

The nursing staff then notified the investigator or a trained research assistant to provide study information, assess eligibility, and obtain consent. Study invitation interviews took place either in the hospital, clinic, on the phone, or in the participant's home. Because the investigator was employed in one of the recruitment sites, she did not make the first contact with potential participants, to reduce any possible undue pressure, but following participant show-of-interest she followed up with candidates by phone to explain the study and to set up a time to obtain consent. Participants were informed that they had the right to withdraw at any point and that their care would not change or be influenced by their participation or lack of participation in the study.

When the potential participants had self-identified in the recruitment setting through the information letter they were approached by the investigator only if they called or expressed an interest to the recruitment nurse. At that time the criteria were reviewed in detail with the potential participants on the phone and then in their home. The medical record was reviewed in some cases to assure that the potential participant met sample criteria. The name and contact information with identification (ID) code for the participant were collected in a master list. Demographic and study data collection forms were labeled with ID# and age only. Consent for participation was obtained after the study was fully explained and the participant willingly signed in the presence of a witness (see Appendix D). Once consented the subjects were assigned a number to assure confidentiality throughout the study.

In many cases subjects were asked at delivery time if it would be okay for a researcher to contact them at about three weeks postpartum to discuss the research project that was being conducted on maternal sleep. At three weeks, if the subject was interested, the study was

explained on the phone and a time for a home visit was set up to review and complete the consent form. Only one subject who agreed to participate on the phone and had a consent visit set up, declined to participate after reviewing the consent form. All but one subject who consented completed the study. She was dropped from the study after having emergency gallbladder surgery three days before the sleep study was to start. One subject declined to have the PSG portion of the study, but did complete wrist actigraphy and all sleep records and demographics. One subject did not complete the PSG portion due to lack of an ethernet cable needed to initiate her study. She declined to repeat the electrode application and testing the next night, but did complete wrist actigraphy and sleep activity records. One breastfeeding mother had self-report data collected by St. Mary's Hospital Sleep Questionnaire and the one night of PSG study, but did not have wrist actigraphy data due to an incorrect battery in the wrist actigraphy (See cohort chart 1).

Data Collection Instruments

St. Mary's Hospital Sleep Questionnaire

This questionnaire (see Appendix E) was used to assess the participant's assessment of the previous night of sleep. It consists of a total of seventeen short-answer items and 4 or 8-point response rating scales and is designed to measure the subjective experience of sleep. The rating scale for "difficulty getting to sleep" was from 1 (none to very little) to 4 (extreme difficulty) and for "depth of sleep" the range was 1 (very light) to 8 (very deep).This questionnaire provided information on the following perceptions: time subjects went to sleep and got up; depth of sleep; how often they woke up; how much sleep they obtained; about naps the day before; how well they slept; what disturbed their sleep; how long it took to fall asleep initially; if they awakened during the night and what woke them up; how clear headed they felt in the morning;

and overall satisfaction with the sleep. The questionnaire was completed on each of four mornings to self-describe the mother's sleep. The first report was done for practice and based on the night before the wrist actigraphy was started. The other three questionnaires were completed in the morning following each of the three nights of wrist actigraphy.

Reliability of this measure has been supported through a test-retest reliability of .70 - .96 in one study (Ellis et al., 1981). Construct validity of the measure was assessed with a factor analysis by Leigh, Bird, Hindmarch, Constable and Wright (1988).'Getting to sleep' and 'quality of sleep' were the two factors that most clearly emerged. Administration requires about two minutes and it can be used daily. For the current study the reliability (consistency) of the items across the three nights was assessed with the ICC (2, 1). Results ranged on the questions about sleep from .47 through .75. For the question "How well did you sleep last night" the ICC = .51; for "How clear headed did you feel in the morning" item, the ICC was .75, for "How satisfied were you with the sleep" the ICC was.47 and for "How difficult it was getting to sleep", the ICC was= .74. Given that there were only three nights of data collected and that sleep varies from night to night in new mothers this level of stability appears adequate. In the current study, the St. Mary's Hospital Sleep Questionnaire was adapted to include questions about factors that might influence sleep, alcohol use, nicotine exposure, exercise, and where baby slept.

Wrist Actigraphy

Wrist actigraphy was used to measure the 3 nights sleep during data collection starting on the first night of the study. Data collection was conducted during the nights selected by the participant and reported as 'typical' sleep nights (times of vacation, holidays, or visiting relatives were avoided). As in Blyton et al. (2002) if the participant reports a poor night sleep the night before the home polysomnography was scheduled, the testing by home polysomnography was

delayed, and the wrist actigraphy would continue to provide a recording of the night before the home polysomnography. This did not occur, but would have decreased the likelihood that sleep deprivation was contributing to the amount of slow wave sleep. The wrist actigraphy was used in this study to record total sleep and number of sleep interruptions and provide a basis upon which to assess if the night of home polysomnography was typical for that participant.

The wrist actigraphy (Mini Mitter© Actiwatch, Bend, Oregon, USA) records movements of the wearer's non-dominant wrist to detect sleep/non-sleep movement and wake after sleep. The wrist actigraphy has a movement sensitivity of > 0.01g, a measure of acceleration (in this case the wrist) (Benson et al., 2004). The wrist actigraphy was set at medium sensitivity (40) meaning it requires 40 activity counts to log a wake epoch and the epoch length was set to record activity every 0.5 minutes. Wrist actigraphy has been validated by polysomnography using minute-by minute comparisons with a 24-hour agreement rate of 91% (Jean-Louis, Kripke, Cole, Assmus, & Langer, 2001). Wrist actigraphy is more reliable than sleep logs in clinical research due to issues of recall of awakenings and periods of sleep (Boone, 2004). In the pilot study with ten participants and using wrist actigraphy for five nights, stability of this measure within subjects was assessed. This was done by treating the scores for the individual nights as a summed scale and conducting reliability analysis. The ICC values for total sleep time was ICC = .87 ($p < .01$), indicating stability/consistency of the reports of sleep time. For sleep interruptions the ICC was .62 ($p = .02$), indicating moderate stability in the reporting of sleep interruptions. In the pilot study participants reported the wrist actigraphy to be comfortable and easy to use, requiring little to no time (Rosen, 2007). The pilot study data were collected on all ten participants without any difficulty with the settings or downloading of information.

For the current study, reliability of the wrist actigraphy data was assessed by determining the stability or the consistency of the wrist actigraphy over the 3 nights using the intraclass correlation (ICC 2,1) obtained from a standard reliability analysis of the composite of the sleep efficiency (time in bed divided by the time asleep) for the three nights, total sleep and sleep interruptions data. For the total group, the ICC for sleep efficiency (the amount of sleep divided by the time in bed) resulted in an ICC of .81 with the breastfeeding group having an ICC of .80 and the formula group having an ICC of.81. This shows stability across the three nights regarding the amount of sleep obtained when in bed and is the measure most reflective of the possible impact the PSG might have had on sleep.

The wrist actigraphy reliability for total sleep time also was evaluated with intra-class correlation assessing stability of the measure over the three nights of the study with an ICC of .57, indicating moderate consistency. The ICCs for all possible pairs of nights, as well as the feeding group ICCs, varied from moderate to strong with one exception, and are reported in Table 1. The ICC was lower in the formula groups throughout.

Table 1

Wrist Actigraphy Intraclass Correlations Minutes of sleep (TST)

	Total N= 43	Breast n=21	Formula n= 22
All nights	.57	.74	.47
Nights 1 and 3	.64	.64	.63
Nights 1 and 2	.26	.50	.18
Nights 2 and 3	.51	.75	.43

Home Polysomnography

Home polysomnography was used to assess sleep architecture for one of the middle nights of the study to measure light sleep, deep sleep and REM sleep and arousals of the participant. Home polysomnography allows the mother to sleep in a familiar environment, producing a more accurate view of her sleep characteristics than might occur if the sleep were assessed in the laboratory. Five channels of data were obtained using the Grass Technologies home monitoring AURA unit. This minimal amount of tracing allowed staging of sleep without overwhelming the participant with leads. Two electroencephalography (EEG) channels, two electrooculography (EOG) channels, and a submental electromyography (EMG) channel were used. Since sleep disordered participants were not included in the sample, no respiratory assessment was done with the home polysomnography. This is consistent with the polysomnography methods in the study done by Blyton et al. (2002).

Training for three members of the research team in the polysomnography application and set-up was done by the staff of an local accredited sleep lab. The research team spent approximately 10 hours reviewing and practicing the application of leads (see Appendix H) and the set up of the equipment for overnight home monitoring (see Appendix H). One of the research team slept with the equipment in place in order to assure that proper application and set up had been done. The registered polysomnographic technologists (RPSGT) at the sleep lab were available by phone to the research team to problem solve any questions that arose when the team went to the participant's homes to set up the study. The research team called the RPSGT's on a number of occasions early in the study to problem solve high impedance checks (times when the contact and readability of the tracing was not optimal) or cable connection issues. After the first 4 subjects, the research team completed the studies without needing significant guidance. Following the night of the PSG study the data were downloaded and transferred from the AURA

system to the laptop computer and hard drive at the sleep lab office. All of the equipment was cleaned and re-packaged for use on the next participant as per protocol of the sleep lab.

The registered polysomnographic technologist (RPSGT) scored the study, providing TST, sleep latency, NREM stages 1 and 2, NREM stages 3 and 4, REM and REM latency scores, as well as wake after sleep onset (WASO) and arousals. The arousal activity was checked for concordance by a second RPSGT.

Staging of the sleep was done according to Rechtschaffen and Kale's criteria (Carskadon & Rechtschaffen, 2005). Sleep stage scoring was divided into REM and NREM, with a further division of NREM into light sleep (stages 1 & 2) and NREM deep sleep (stages 3 & 4) which includes high-voltage slow wave activity (SWS). REM sleep was distinguished by the rapid eye movement, lack of EMG activity and desynchronized EEG activity. Blind to feeding method sleep staging was performed on all the studies by an RPSGT with 22 years of experience who strictly adhered to Rechtschaffen and Kales criteria (Carskadon & Rechtschaffen, 2005). An independent RPSGT with 8 years of experience scored arousals separately and there was a high level of concordance of 94.1% between technologists. Agreement was determined by randomly selecting and evaluating 12% of of the sleep records and 10% of the epochs within each record. A level of 90% agreement or above was anticipated based on Blyton et al. (2002) who reported a 93% overall agreement on studies, although they did not specify how they verified agreement. For the current study, a total of 5 PSG studies were reviewed with two recorders marking concordance. The method of infant feeding was not known to the technicians reading the studies to reduce any bias from this knowledge. The lowest agreement rating was for a PSG study that had sweat artifact and therefore was more challenging to score (see Table 2). Agreement ranged from 89% to 97.2%.

Table 2

Percent Agreement- Polysomnographic Technologists on Number of Arousals per Study

Test #	Percentage of Agreement
# 1	89%
# 2	96.6%
# 3	97.6%
# 4	90.5%
# 5	97.2%
Overall Agreement	94.1%

The sleep studies were replayed on Grass technology Twin series and each sleep stage was based on a 30-s epoch. The total sleep time and minutes for each stage were assessed and then percentages of total time spent in each stage of sleep were calculated. Slow wave sleep, stage 3 and 4 were scored on the basis of at least 20% delta activity in the epoch. Arousal analysis was performed according to the standard criteria established by Guilleminault (1992) with the American Sleep Disorders Association (ASDA), which scores arousals when alpha intrusion into the EEG occurs for at least 3 seconds and an increase in amplitude of the submental EMG occurs during rapid eye movement (REM) sleep. This method of arousal analysis was consistent with that of Blyton et al. (2002).

Concurrent validity between the tools for sleep measurement was assessed by correlating scores for the wrist actigraphy sleep parameters with those measured with the polysomnography (considered the gold standard of sleep measurement). For this study the correlation of total sleep time between wrist actigraphy and polysomnography was $r = .91$, indicated strong support for concurrent validity. A moderate correlation was found between St, Mary's Hospital Sleep Questionnaire and wrist actigraphy with $r = .47$ and St. Mary's Hospital Sleep Questionnaire and polysomnography with $r = .45$.

Edinburgh Depression Scale

The Edinburgh Postnatal Depression Scale, EPDS, (Appendix F) was developed in health centers in Livingston and Edinburgh England in 1987. This scale was used after consent and immediately prior to the onset of data collection to assess depressive symptoms that might impact sleep. This measurement tool is a 10-item questionnaire of short statements of common depressive symptoms. It was developed to assist primary care health care professionals to screen for a broad population for post-partum depression. The screen excludes fatigue and appetite variations, which the developers viewed as normal variation during the postnatal period.

The EPDS questions a woman's feelings over the past 7 days. Questions were scored on a 4-point scale (0-3). Scores may range from 0-30. Studies have varied on what cut score indicates post-partum depression. Some studies state a score of 10.5 or greater is indicative of post-partum depression, while others state 14.5 or greater as being indicative (Adouard, Glangeaud, Freudenthal, & Golse, 2005). The EPDS has undergone accuracy (validity) assessment including specificity of 78%, sensitivity of 86%, and positive predictive value at 73% (Cox, Holden, & Sagovsky, 1987). It takes about five minutes to complete the EPDS. The EPDS may be used in the antepartum and postpartum periods and currently is the most commonly used screen in the postpartum period (Boyd, Le, & Somberg, 2005). Reliability on the Edinburgh postpartum depression scale was assessed using Cronbach's alpha, The total group scores ranged from zero to ten, with a mean of 4.42 ± 2. In the breastfeeding group the scores ranged from 1-9 with a mean of 3.9 ± 2.74 and the formula feeding group had a range of 0-10 with a mean of 5.12 ± 2.68. Two of the questions were not given any points by all the participants. These were question 10, "the thought of harming myself has occurred to me" with all subjects answering "never" and question 2, "I have looked forward with enjoyment to things", with all subjects

answering “as much as I ever did”. There was a range of zero to two or three on the remaining questions. Total alpha was adequate ($\alpha = .73$) for the total sample higher for the breastfeeding subgroup ($\alpha = .82$), and lower for the formula group ($\alpha = .66$). This was administered before their sleep was monitored.

Demographic Data

Demographic information was collected after informed consent was obtained (see Appendix G). At a phone call between weeks two and three postpartum the investigator asked about infant feeding method and if there were any questions at this time and to set up the day to begin data collection. The weight gain of the baby was assessed with an infant scale at the beginning of the data collection on day one of the study. This is the same type of scale used at the birth of the baby and it is calibrated to a tenth of an ounce. Weight gain of approximately one pound over birth weight was expected at one month of age (Lawrence, 2005).

Method of feeding for the baby was determined by self-report and the exclusivity of breastfeeding was defined as no use of formula. Exclusive formula-feeding was defined as not putting the baby to breast or pumping since 14 days postpartum and only offering formula. Having another adult in the house was defined as having another adult available to assist with activities of daily living. Having the criteria of another adult in the household reduces the variance that might occur if the subject is performing activities of daily living without assistance.

Data Collection Procedures

If the participant met eligibility requirements and decided to participate in the study, participation lasted until approximately six weeks after birth. Data collection occurred during the fourth, fifth, or sixth week postpartum beginning when the participant preferred and reported the preceding night was a ‘typical’ night’s sleep. Data collection lasted 72 hours for at least three

nights of wrist actigraphy data collection and one night of home polysomnography data collection. These participant driven times were used to avoid any possible change in sleep patterns related to unusual or difference in activities.

As soon as informed consent was obtained the participants provided baseline information regarding usual sleep patterns, delivery (See Appendix G) as well as contact information. Participants were contacted at 3 weeks post delivery to set up the study initiation time in the fourth, fifth or six week when they were instructed on the use of the sleep questionnaire and the wrist actigraphy.

The Mini Mitter Actiwatch© remained on the participants' non-dominant wrist 24 hours per day for the three days of data collection. The Actiwatch can be worn while bathing, swimming, washing dishes, or while feeding or caring for the baby. The Actiwatch records the level of activity throughout the day and night. The participant also kept records using the St. Mary's Hospital Sleep Questionnaire during the days of data collection. At the participant's home on the first evening of data collection they completed the questionnaire regarding previous night sleep for the purpose of practice and then upon awakening each morning of the study to note sleep and wake time and the quality of their sleep. The investigator went to the participant's home to pick up the wrist actigraphy and the sleep questionnaires at the end of the data collection period or when coming to remove the home polysomnography if it was completed on night three. For those who completed the home polysomnography at the end of night two, the leads and data were collected the morning after. If the leads loosened or the home polysomnography did not record adequate data, the participant was asked if they were willing to have the polysomnography used on the third night. This happened with only one subject who did not turn on the polysomnography recorder when she went to bed. At any time the participant could

withdraw from the study by simply informing the investigator, but this did not occur. One subject declined repeated polysomnography when the wrong Ethernet cable was brought to the house.

On the preferred evening, the investigator or research assistant went to the subject's home to connect the home polysomnography. Thirteen wire leads, providing five channels were attached to the subject's head with conductive paste: two EEG channels, two electrooculogram (EOG) channels as well as four redundant EEG leads, the right and left outer canthus, and three leads for the submental electromyogram channel. The leads were connected to the AURA unit, a small box that recorded the data. The investigator returned in the morning to collect the leads and the AURA unit to download the sleep data for that night.

Data from the three nights of wrist actigraphy and one night of home polysomnography were downloaded at the sleep lab and de-identified except for participant's ID number. The collected data (stored inside the wrist actigraphy) were downloaded to a computer for display and analysis of activity by the researcher and the RPSGT for the home polysomnography. The bedtime and wake time were entered on the polysomnography as documented on the St. Mary's Hospital Sleep Questionnaire. On the third day at the end of data collection, when collecting the wrist actigraphy, questionnaires, and home polysomnography, the investigator provided the participant with a package of diapers for the baby in appreciation for participation. At each of the other visits a small token of infant bib, wash cloth, bath towel or book was given to the mother for her baby. After the data were analyzed the participant was given a copy of her own sleep parameters for the nights the data were collected.

Data Management

A comprehensive database of 210 variables was developed that included the demographic data, depression scale, sleep questionnaire, wrist actigraphy and polysomnography sleep characteristic data of the 44 subjects. Each subject's data were kept in a folder with their ID number only. Accurate data entry was confirmed by having a research assistant recheck each data entry. Second reviews of any changes were made by another research assistant to confirm the accuracy of the data entered. The data were analyzed using the Statistical Package for the Social Sciences Version 16. A criterion significance level of .05 or less was chosen for all statistical tests.

Data Analysis

The purpose of the study was to describe and assess the differences in total sleep time and the sleep parameters of light sleep (N1, N2), deep sleep (N3,4) and REM sleep as well as wake after sleep onset in breastfeeding and formula-feeding mothers at four to six weeks postpartum in a sample of first time mothers. The research questions for the study were to determine 1) What are the differences in sleep architecture characteristics including total sleep time, light sleep, deep sleep, REM sleep and wake after sleep onset between breastfeeding (fully lactating) and formula-feeding mothers at four to six weeks postpartum and 2) What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?

Demographic Information

The demographic data were entered into a statistical program for analysis and analyzed using descriptive statistics. Descriptive statistics included the range, mean and standard deviations of maternal age and BMI, infant weight at birth and at four weeks. In addition, information regarding the following was collected: level of income in the household, educational

level, race/ethnicity, marital status, length of labor, current medications, self-report of hours slept before and during pregnancy and in the last two weeks, and subjective report of number of sleep interruptions before and during pregnancy and in the last two weeks. Data regarding feeding method, number of bottles given in a 24 hour period, and where baby slept was also collected.

St. Mary's Hospital Sleep Questionnaire

The data from the St. Mary's Hospital Sleep Questionnaire were entered into a SPSS16 data file for data analysis. The reasons for sleep interruptions were categorized for data entry as related to baby, personal care, nourishment, or inability to sleep-awake without activity. These data were used to enhance the interpretation of sleep interruption findings from the wrist actigraphy and the polysomnography.

Research Question One

What are the differences in sleep architecture characteristics including total sleep time, light sleep, deep sleep, REM sleep and wake after sleep onset between breastfeeding (fully lactating) and formula-feeding mothers at four to six weeks postpartum?

For the home polysomnography sleep architecture data, total sleep time (TST) between groups was compared using a t-test. Total sleep time has a strong correlation with the other stages of sleep therefore potentially impacting the results of the MANCOVA if included. MANCOVA was used to compare the two groups on the parameters of light sleep (N1, N2), deep sleep (N3,4), REM sleep and arousals. The co-variates of age, educational level, and nicotine use were used due to the significant differences in educational level and nicotine use between groups and the frequency of younger mothers in the formula-feeding given the knowledge that age may impact sleep.

Research Question Two

What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactation) and formula-feeding mothers at four through six weeks postpartum?

Data from the wrist actigraphy measurements were descriptively analyzed by calculating the mean and standard deviation for all participants for each sleep measure. Range of total sleep time and number of sleep interruptions were calculated. For the categorical data, chi-square was utilized to determine differences between the groups.

The wrist actigraphy data were downloaded and total sleep time and the number of awakenings after sleep onset (sleep interruptions) were computed. These data were entered into a statistical program for analysis and a spreadsheet program for graphic displays. Sleep interruptions for wrist actigraphy were noted as any periods of wake greater than five minutes embedded in a sleep period. Wrist actigraphy, polysomnography, and self-report data were compared to determine differences by reporting method.

Ethical Considerations

The study had the approval of Kansas Univeristy Medical Center Human Subjects Committee (HSC) and the approval of the Topeka hospitals IRB before beginning study activities.

The standard care for the patient population being studied was to give birth and go home in two to three days postpartum. Patients in the Topeka community have access to the breastfeeding and follow-up clinic for weight checks as frequently as they or their doctors desire. Participants would typically see their pediatrician by day 14 after delivery and at one month and

have a 6 week check-up with their health care provider. No sleep study would be done within this standard care. No changes in standard of care occurred; this was not an intervention study.

To assure privacy throughout the study after recruitment, the participants were identified by a code number instead of their name on all data collection tools. The master list with the name and ID number, as well as address, phone number, date of delivery was kept separate from the data collection forms in a locked cabinet. Each participant was identified by number only in SPSS and on all forms. The wrist actigraphy was coded by the code numbers only. The only people with access to the master list was the researcher and her mentors. The home polysomnography record had ID number only for identification. Data were stored in a locked cabinet.

The only risk identified for this study was the burden of time for meeting with the investigator to learn about the study, obtain informed consent, complete the Edinburgh Post Partum Depression Scale, and to fill out the St. Mary's Hospital sleep questionnaire each day for the 3 days, The time to begin and end the home polysomnography on the second or third night and be instructed on the wrist actigraphy required about 1-2 hours. This time burden occured when the new family was getting adjusted to parenthood and had changes in sleep patterns, and at a time when they may already feel challenged yet before they return to work outside the home.

The potential benefit for the individual was minimal, simply an increase in awareness of sleep patterns. However, overall for new families, this study was a confirmatory study that may impact understanding of differences in sleep patterns related to feeding method and could provide evidence to support choices and decisions as well as strategies to assist new families in maximizing the sleep they obtain and coping with the interruptions in sleep inevitable to the transition to parenthood. Information about the website for the National Sleep Foundation and

American Academy of Sleep Medicine was provided when the results of the individual sleep patterns was sent to the participants.

All recruiters and research investigators completed HIPPA and HSC training through the KUMC Office of Research Compliance. The polysomnography certified technicians did not have access to any identifiable data and blindly determined sleep architecture.

Participants voluntarily consented to this study (see Appendix D) and were made aware that they could withdraw at any point in time. There were no known risks to taking part in the study. New mothers were very busy learning their new role as a mother. Taking time to complete anything besides caring for self and baby may have been stressful.

The wrist actigraphy could be worn in the shower or anywhere that subjects would normally go; however it might have been irritating to wear it for 3 days straight, therefore, wrist bands were provided to minimize discomfort or potential metal sensitivity. Wearing the home polysomnography leads may have been distracting or irritating, however no risks have been identified in using of this assessment tool. There may be other risks that were not identified.

If any abuse or neglect of mother or baby was noticed the investigator was obligated to report it to the appropriate authorities. No such occurrence was observed.

The participant was unlikely to benefit from participating in this study. There were no costs to the participants for participating in the study, and no monetary payments were given to the subjects. At each stage of the home data collection the participant received a newborn item and at the completion of the data collection, subjects received a package of diapers for the baby.

Summary

This chapter summarized the methods for this dissertation study. The setting and sample, inclusion and exclusion criteria, the recruitment and data collection procedures, the data

collection tools, and the data analysis that were used were described. In addition the ethical considerations made for this study were identified.

Chapter IV

Study Findings

Introduction

The purpose of this study was to determine if there were differences in the sleep architecture, sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum. Results of data analysis are presented in this chapter relating to each of the two research questions as well as demographic descriptions of the two groups.

Description of the Sample

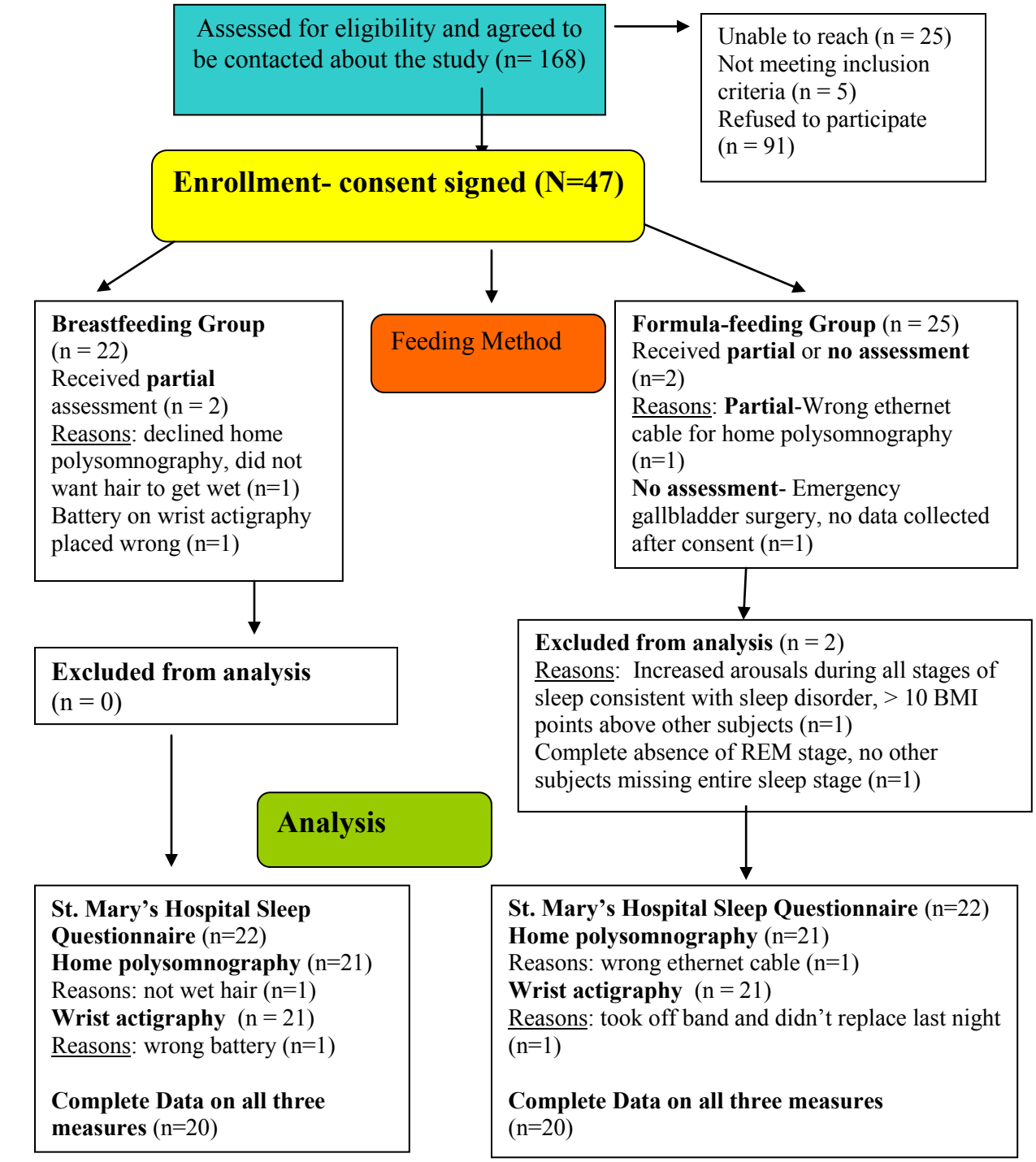
Of the 168 women who agreed to be contacted about the study, 47 consented to participate. Twenty-five mothers were unreachable or had disconnected phones. Five mothers who had expressed interest were determined ineligible during the phone follow up, four due to age (younger than age criterion) and one mother had a history of a sleep disorder. The most common reasons for non-participation among the remaining 91 women included "time", "too busy", "not sure I want to", and "my partner doesn't want me to."

Twenty-two of the participants were breastfeeding exclusively at the time of the study and 25 were formula feeding. Three of the participants who were formula feeding their infants were excluded prior to data analysis. An additional participant had an incorrect battery in the wrist actigraphy but had all other data completed (see Figure 2).

Participants Excluded Following Consent and/or Data Collection

Of the 47 participants that consented, 44 completed home polysomnography and two were excluded prior to data anaylsis. Polysomnography was not completed on one participant as the wrong connective cable was taken to the home and the mother did not want to delay bedtime

Figure 2. Participation Attrition in Sleep Characteristics in Breastfeeding/ Formula Feeding Mothers



for her partner. She did not offer to repeat the test the next night. One participant declined to do the home polysomnography study because she was concerned that it would interfere with the

straightening product that she used on her hair. One participant did not turn on the polysomnography recording unit when she went to bed. She offered to repeat the testing the next night, which was done. Two participants had an excessive amount of perspiration, which led to sweat artifact inhibiting the ability of the technicians to identify slow wave sleep, but all other sleep characteristics were scored and used in the data analysis. This left 42 subjects, 21 in each feeding group who completed the polysomnography. The equipment worked on all of the nights. Ninety-five percent had complete data sets, as two subjects had sweat artifact which complicated the reading of their SWS and required imputation of the variable based on TST and N1 sleep.

Three participants' data were not used for analysis of research question one. One participant had increased arousals during REM and all other sleep stages and only slept a short time because her sleep was interrupted by a lengthy telephone call. Upon close examination of this participant's demographic data it was found that her BMI was 10 points above all of the others. Therefore, considering her data as an outlier, the data analyses were conducted with and without her data and revealed the group variance was markedly increased when her data were included. People with morbid obesity (49.5) are significantly more likely to have sleep disorders (Takegami et al., 2009) and her arousal score was well above the other subjects, thereby indicating a possible sleep disorder. Therefore, all analyses were performed without her data.

One subject had complete absence of the REM stage of sleep. After scoring the PSG, the sleep technologist reported an absence of REM sleep and only 2 hours and 59 minutes of TST. This was significantly different than the 7 hours her wrist actigraphy recorded the night before and after the polysomnography night and very close to the 3 hours the wrist actigraphy recorded that night. The subject reported to the investigator following her polysomnography sleep study night that she had been very anxious about the lead wires coming off and that she had "not

slept." She also told the investigator that she had a job interview the next day. By the time that her polysomnography was analyzed by the sleep technologist, she was out of timeframe for the study. Her data were excluded as all other subjects had varying amounts of every stage of sleep represented in their polysomnography analysis.

A third formula-feeding participant consented and then had emergency gallbladder surgery before the sleep data collection began. One participant had a wrist actigraphy with a defective battery and her sleep was not recorded. Her PSG and self-report data were collected and utilized in the data analysis. One subject took off her wrist band the third night and did not have her sleep recorded for that night.

Maternal Characteristics

The final sample was composed of 44 first time mothers who lived with another adult. The majority (82%) of the participants were Caucasian. No participants had a history of sleep disorders, and they were either exclusively breastfeeding or exclusively formula feeding their infants. Two of the breastfeeding participants pumped and bottle-fed their breast milk an average of two times a day in addition to feeding the baby at breast (See Table 3).

Although there were a greater number of low household income participants in the formula feeding group, the difference did not reach a level of significance. There were no differences between groups on any of the demographic variables except education level and smoking status (See Table 6). Eleven participants in the study had cesarean births. This constitutes 25% of the participants, slightly below the average of 29.8 % for the state of Kansas in 2007 and below the national average of 31.8% (National Vital Statistic Reports, 2009).

Table 3

Demographic Profile of Total Sample and Infant Feeding Subgroups

Characteristic	Total	Breast	Formula

			N= 44	n=22	n= 22
Age	Range		20-36	21-34	20-36
	Mean (SD)		25.82(4.04)	26.64(3.59)	25(4.36)
Marital Status -Married			25 (57%)	15 (68%)	10 (46%)
	Unmarried with partner		11 (25%)	3 (14%)	8 (36%)
	Single, never married		8 (18%)	4 (18%)	4 (18%)
Race /Ethnicity					
	African-American		7 (16%)	2 (9%)	5 (23%)
	Caucasian		36 (82%)	19 (86%)	17 (77%)
	Hispanic		1 (2%)	1 (5%)	0 (0%)
BMI	Range		18.9-40	20-39.3	18.9-40
	Mean(SD)		27.10(5.88)	28.22(5.32)	25.99(6.32)
Income	Less than $15,000		6 (14%)	1 (5%)	5 (23%)
	$15,001-$30,000		9 (20%)	4 (18%)	5 (23%)
	$30,001-$45,000		3 (7%)	3 (14%)	0 (0%)
	$45,001-$60,000		6 (14%)	3 (14%)	3 (14%)
	$60,001-$75,000		2 (5%)	1 (5%)	1 (5%)
	$75,001-$90,000		13 (30%)	8 (36%)	5 (23%)
	Over $90,000		5 (11%)	2 (9%)	3 (14%)
Education					
	Less than high school		1 (2%)	0 (0%)	1 (5%)
	High School		7 (16%)	1 (5%)	6 (27%)
	Junior College		11 (25%)	5 (23%)	6 (27%)
	College		22 (50%)	14 (64%)*	8 (36%)*
	Graduate School		3 (7%)	2 (9%)	1 (5%)
Mode of Delivery		Cesarean	11 (25%)	4 (18%)	7 (32%)
		Vaginal	33 (75%)	18 (82%)	15 (68%)
	Length Labor	Mean(SD)	10.22(6.3)	10.7 (6.9)	9.7(5.7)
Help with the nighttime care of the baby					
Yes			19 (43%)	10 (45%)	9 (41%)
No			25 (57%)	12 (55%)	13 (59%)

*P < .05

The Edinburgh Postpartum Depression Scale was used to screen participants for depression because it is an influencing factor in sleep pattern outcomes. A cut score of greater than ten was used to screen and exclude those with depression symptomatology. No mothers

were excluded due to elevated scores and no one scored greater than 10. The feeding groups were not significantly different in depression scores, the breastfeeding group mean (SD) was 3.9 (2.7) and the formula-feeding group mean (SD) was 5.1 (2.7). Eleven participants had a history of depression and that was typically during adolescence and situational. Nine of those with a history of depression took medication, but none of the participants had been on depression or anxiety medications during the last two years, during the pregnancy, or since the delivery. No participants were currently on medication for depression. There were no differences in REM sleep total by depression scores.

Infant Characteristics

Infant characteristics were similar between feeding groups (see Table 4). Age at data collection/sleep study ranged from 27 days to 46 days of age. All infants had gained at least a pound above their birth weight by 4 weeks of age. All the infants were in the normal newborn nursery and were discharged without any health care issues or concerns. There was a difference between groups on the question of who was the primary caretaker of the baby. All of the breastfeeding participants reported that they were the primary caretakers of the baby. Three of the mothers in the formula feeding group reported that they were not the primary caretaker of the baby.

Where the baby slept was identified in the demographic questionnaire. Two participants had visual monitors to observe their babies while sleeping. Only 9 participants reported that their babies slept in their own room. The other 35 either had a crib or bassinette in the participant's

Table 4

Infant and Birth Characteristics

Characteristic	Total	Breast	Formula

	N= 44	n=22	n= 22
Infant age			
Range	27-47	27-42	28-47
Mean (SD)	33.95(5.84)	34.36(4.93)	33.55(6.72)
Infant weight in grams at birth			
Range	2693-4139	2693-4054	2750-4139
Mean (SD)	3312 (385)	3281 (418)	3342 (355)
Infant weight in grams at time of study			
Range	3360-5131	3360-4990	3629-5131
Mean (SD)	4304 (437)	4246 (429)	4368 (454)
Infant weight gain from birth to study			
Range	453-2098	510-1644	453-2098
Mean (SD)	1000 (376)	958 (337)	1042 (416)
Primary Caregiver of the baby			
Participant	41 (93%)	22 (100%)	19 (86%)
Other adult in the house	3 (7%)	0 (0%)	3 (14%)

room (34%), shared their bed with the baby (13.6 %), or a combination of the two (31.9%). However when the participants reported on the actual nights of sleep, the number of babies who exclusively shared the bed with the participants rose to 30.11% across the four self-reported nights. The combination of the solitary surface and parents' bed dropped to 17%, in addition parents reported that babies slept on "other" surfaces only on the actual nights of sleep at the rate of 2.8%. These "other" surfaces included couches, chairs or car seats. There was no statistically significant difference between groups on infant sleep environment (See Table 5).

Table 5

Infant Sleep Environment

Where Baby Sleeps	Total N= 44	Breast n=22	Formula n= 22

Where the baby slept overall			
A. Crib/bassinette in baby's room	9 (20%)	4(18%)	5 (23%)
B. Crib/bassinette in parents room	15 (34%)	9 (41%)	6 (27%)
C. In participants bed	6 (14%)	3 (14%)	3 (14%)
Combination of A&C or B&C	14 (32%)	6 (27%)	8 (36%)
Practice Night			
A. Crib/bassinette in baby's room	8 (18%)	4 (18%)	4 (18%)
B. Crib/bassinette in parents room	14 (32%)	6 (27%)	8 (36%)
C. In participants bed	13 (30%)	7 (32%)	6 (27%)
Combination of A&C or B&C	8 (18%)	4 (18%)	4 (18%)
Other (couches/chairs)	1 (2%)	1 (5%)	0 (0%)
Night 1			
A. Crib/bassinette in baby's room	8 (18%)	4 (18%)	5 (23%)
B. Crib/bassinette in parents room	15 (34%)	7 (32%)	8 (36%)
C. In participants bed	12 (27%)	7 (32%)	5 (23%)
Combination of A&C or B&C	8 (18%)	4 (18%)	4 (18%)
Other (couches/chairs)	0 (0%)	0 (0%)	0 (0%)
Night 2 (PSG night)			
A. Crib/bassinette in baby's room	8 (18%)	3 (14%)	5 (23%)
B. Crib/bassinette in parents room	13 (30%)	8 (36%)	5 (23%)
C. In participants bed	13 (30%)	7 (32%)	6 (27%)
Combination of A&C or B&C	7 (16%)	3 (14%)	4 (18%)
Other (couches/chairs)	3 (7%)	1 (5%)	2 (9%)
Night 3			
A. Crib/bassinette in baby's room	7 (16%)	4 (18%)	3 (14%)
B. Crib/bassinette in parents room	13 (30%)	6 (27%)	7 (32%)
C. In participants bed	15 (34%)	10 (45%)	5 (23%)
Combination of A&C or B&C	7 (16%)	2 (9%)	5 (23%)
Other (couches/chairs)	1 (2%)	0 (0%)	1 (5%)

Other Factors that Impact Sleep

Other factors that might influence sleep were identified in the St. Mary's Hospital Sleep Questionnaire on the morning following each study night (see Table 6). Participants reported

small amounts of alcohol consumption. On the practice recording night 14% of the participants reported to have consumed alcohol. That number decreased to 5% across the other three nights with subjects reporting only one drink consumed.

Many participants (59%) were still taking prenatal vitamins with the majority of those in the breastfeeding group. Other reported medications in order of frequency were acetaminophen, stool softeners, ibuprofen, allergy medication, synthroid and antibiotics. Eight percent of the participants reported taking allergy medication in the last two weeks, but not on the nights of the sleep study. One participant on antibiotics reported having a urinary tract infection ten days prior with no remaining symptoms. No medication that would impact sleep was being taken by the participants.

Table 6

Potential Influential Factors on Sleep

Characteristic (frequencies) Number of subjects answering yes		Total N= 44	Breast n=22	Formula n= 22
Alcohol	Practice Night	6 (14%)	3 (14%)	3 (14%)
	Night 1	3 (7%)	1 (5%)	2 (9%)
	Night 2	1 (2%)	1 (5%)	0 (0%)
	Night 3	2 (5%)	1 (5%)	1 (5%)
Medications	Practice Night	26 (59%)	18 (82%)	8 (36%)
	Night 1	20 (45%)	13 (59%)	7 (32%)
	Night 2	20 (45%)	13 (59%)	7 (32%)
	Night 3	23 (52%)	15 (68%)	8 (36%)
Nicotine	Practice Night	10 (23%)	1 (5%)*	9 (41%)*
	Night 1	9 (20%)	1 (5%)*	8 (36%)*
	Night 2	10 (23%)	1 (5%)*	9 (41%)*
	Night 3	9 (20%)	1 (5%)*	8 (36%)*

Table 6 (continued)

Exercise	Practice Night	10 (23%)	7 (32%)	3 (14%)
	Night 1	5 (11%)	3 (14%)	2 (9%)
	Night 2	5 (11%)	3 (14%)	2 (9%)
	Night 3	5 (11%)	3 (14%)	2 (9%)

*Group Difference $p < .05$

Nicotine consumption was reported from 1 cigarette to 1 pack a day. The mode was 3-4 cigarettes, stopping in the late afternoon. All participants reported that they smoked only outside. The one smoking mother in the breastfeeding group reported that she smoked from 3-5 cigarettes a day. Smoking was more prevalent in the formula feeding group across all the data collection periods ($t(42) = 3.12$, $p = .003$) (see Table 7).

Table 7

Reports of Nicotine Consumption

Number of cigarettes/day		Breast n=1	Formula n= 9
Practice Night	Range	4	2-10
	Mean	4	5.3
Night 1	Range	4-5	2-15
	Mean	4.5	6.2
Night 2	Range	4-5 cig	1-10
	Mean	4.5	4.7
Night 3	Range	3-4 cig	1-20
	Mean	3.5	5.3

Exercise reports were greater in the breastfeeding group during the baseline data collection and significantly different between feeding groups ($\chi^2 = 6.286$, (1), $p = .012$). However exercise on the nights of the study was not significantly different between groups. Participants most commonly reported walking and yoga. A few participants reported that they exercised with a TV or DVD routine. Some mothers reported that they used to exercise, but not regularly, and hoped to get back to exercise soon.

Assessment and Management of Missing Data

Although there were no missing data per se in the home polysomnography recording, for two participants, one in each group, slow wave sleep (SWS) was not readable due to sweat artifact, even after adjusting the amplitude of the tracings. All other sleep parameters for the remaining participants were measured and scored Therefore, imputation of the missing SWS variable was estimated for the two participants using three different methods. First, substitution of the mean values for slow wave sleep (SWS) in minutes for each feeding group were substituted for the "missing" values. The second imputation method used a regression equation with SWS as the dependent variable and total sleep time as the independent variable was used to estimate the individual SWS values. Finally, for the third method a regression equation was estimated with SWS as dependent variable and TST and Stage 1 (N1) minutes as independent variables.(see Table 8) N1 minutes were included because they had the lowest correlation with TST and thereby the highest probability of providing independent information in the equation. b weights were used to compute SWS minutes.

Four data sets were developed from the imputation estimation procedures: the first without the two subjects with missing SWS values and the others with different imputation procedures. The first imputation was with the SWS mean substitution used; the second with the imputed variable based on the TST regression; and the third with the imputed variable based on TST and N1 minutes regression (see Table 9). The SWS value using the third method was considerably less than that using the first or second imputation methods. This method however, was most similar to the other subjects who had greater than 70 minutes of N1 sleep. Blyton, Edwards and Sullivan reported that the subjects who had high percentages of SWS, had it at the expense of their N1 sleep. Separate MANCOVA analyses for research question one using the four data sets were conducted with similar results. Therefore, the fourth data set with the SWS

variable imputed by regression on SWS with TST and N1 minutes of sleep was used for the final analysis.

Table 8

Relationship of SWS to Other Sleep Characteristics

Summary of Regression Analysis for Variables Predicting Slow Wave Sleep *Breastfeeding (n=20) Formula Feeding (n=20)*				
Variable		b	*SE* b	β
Regression by TST				
TST	Breastfeeding	.217*	.072*	.578*
	Formula Feeding	.067	.062	.250
Regression by TST and N1				
TST	Breastfeeding	.206*	.070*	.548*
	Formula Feeding	.165*.	.060*	.609*
N1	Breastfeeding	-.437	.286	-.285
	Formula Feeding	-.880*	.286*	-.689*

* p< .05

Table 9

Slow Wave Sleep (SWS) Missing Data Imputation Methods on Polysomnography

Subjects with missing SWS not included in analysis	Breast n=20	Formula n= 20
Means(SD) minutes of SWS	57.13(24.06)	53.35(23.63)
% of SWS	14.69(5.19)	13.41(5.99)
Imputation using SWS Mean Substitution		
TST (minutes)	410	423
Minutes of SWS/TST minutes	57.13	53.35
Table 9 (continued)		
Recalculated % of SWS	14.25%	12.61%
Imputation using Regression SWS with TST		
Minutes of SWS	60.7	54.10

Recalculated % of SWS	15.14%	12.79%
Imputation using-Regression of SWS with TST and N1		
Minutes of SWS	63.35	28.06
Recalculated % of SWS	15.8%	6.6%

Research Question One

What are the differences in sleep architecture characteristics including total sleep time (TST), light sleep (N1, N2), deep sleep (N3,4), REM sleep and number of awakenings after sleep onset between breastfeeding (fully lactating) and formula feeding mothers at four to six weeks postpartum?

For total sleep time (TST) a t-test was conducted to determine feeding group differences because total sleep time is highly correlated to the other sleep parameters and would violate statistical assumption for the MANCOVA. A MANCOVA with education level, nicotine use, and age as covariates was used to compare the groups on the remaining sleep parameters (N1, N2, SWS, REM, and arousals). Although mean age was not significantly different between the groups, there were more 20 year olds in the formula group with 41% of that group being under 24 years of age compared with 18% of the breastfeeding mothers and age has been associated with sleep differences.

Percentages of sleep stages were calculated from the polysomnography data for the total group and individual groups (See Table 10).

Table 10

Sleep Architecture from Polysomnography

Characteristic in Percentage	Total N= 42	Breast n=21	Formula n= 21

Light Sleep N1			
Range	5.2-27.5	5.2-27.5	6.5-18.1
Mean(SD)	11.57(4.4)	11.24(4.7)	11.37(3.7)
Light Sleep N2			
Range	42.5-70.7	45.2-70.7	42.5-66
Mean(SD)	55.5(6.3)	54.61(6.8)	56.39(5.7)
Slow Wave Sleep (N3,4)			
Range	3.4-25.4	3.4-25.4	4.2-22.7
Mean (SD)	13.92 (5.6)	14.75(5.1)	13.09(6.0)
Rapid Eye Movement (REM)			
Range	7.2-30.9	8.2-27.7	7.2-30.9
Mean (SD)	19.02(5.2)	18.88(4.9)	19.15(5.6)
Total NREM			
Range	69.1-92.8	72.2-91.8	69.1-92.8
Mean(SD)	80.98(5.2)	81.1(4.9)	80.8(5.6)
WASO	3-37.3	15-35.2	3-37.3
Mean	22.8 (5.6)	23.7 (4.9)	21.9 (6.2)
Arousal Index			
Range	6.1-23.7	8.3-23.7	6.1-20.4
Mean (SD)	13.4(4.3)	13.85(4.4)	12.96(4.2)

There was no statistically significant difference in total sleep time between the feeding groups ($t = -1.05$, (40), $p = .299$). Next, a multivariate analysis of covariance was conducted to assess if there were differences between breastfeeding and formula feeding groups on the percent of stages of N1, N2, SWS (N3,4), REM and arousals and wake after sleep onset in sleep controlling for age, educational level, and nicotine use. Table 11 is a report of the findings of the MANCOVA. Levine's test showed no significant differences, confirming the assumption of equal variances. There were no significant differences between the feeding groups on any of the sleep architecture parameters.

Table 11

Multiple Analysis of Covariance for Sleep Characteristics

Sleep Characteristic	df	F	partial eta squared	p
		Between Subjects		
Light Sleep N1	4	0.25	.027	.91
Light Sleep N2	4	0.86	.085	.49
Table 12 (continued)				
SWS (N3,4)	4	0.51	.052	.73
REM (Rapid Eye Movement)	4	1.46	.136	.24
Arousal Index	4	0.16	.017	.96
Error	37			

Research Question Two

What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?

Total sleep time and sleep interruptions were recorded with polysomnography, wrist actigraphy and self report. Participants reported between 2-3 awakenings per night (see Table 12 and 13). The most common reason (95%) for awakening, as indicated by responses to questions on the SMHSQ, was feeding of the baby. The other 5% of reasons for awakenings were reported as restlessness, dogs barking, unsure why awake, or going to the bathroom.

Table 12

Polysomnography (PSG) and Wrist Actigraphy (WA) by group

Characteristic PSG & WA	Total N= 40	Breast n=20	Formula n= 20

Polysomnography

Total Sleep Time (minutes)			
Range	246-551	246-475	256-551
Mean(SD)	396.79(72.97)	389.28(61.21)	404(84.05)
Distribution-			
Skewness	-.16	-.59	-.13
Kurtosis	-.50	-.17	-.86

Wrist Actigraphy (Night 2 – polysomnography night)

Total Sleep Time (minutes)			
Range	285-538	285-520	296-538
Mean	416.40(65.56)	412.65(57.04)	420.15(74.43)
Distribution			
Skewness	-.24	-.20	-.34
Kurtosis	-.47	.60	-.90
Wake after Sleep Onset (WASO) or minutes awake after sleep onset			
Range	14-324.5	57-324.5	14-254.5
Mean (SD)	117.3 (63.4)	121.1 (59.2)	113.4 (68.5)
Number of Sleep interruptions			
Range	0-6	1-5	0-6
Mean	2.28(1.26)	2.25(1.12)	2.3(1.4)

Results of the total sample showed that the mean amount of sleep for these participants by wrist actigraphy was 7.5 hours for night one, 7.03 hours for night two and 7 hours for night three with an average of 7.18 for the three nights by wrist actigraphy. The sleep efficiency of this group of participants averaged 73.4%, (i.e. the amount of time asleep divided by the amount of time in bed). Sleep interruptions averaged 2.4 times per night (see Tables 12, 13, & 14).

The participants reported on the amount of sleep that they felt they had obtained before pregnancy, during pregnancy and since delivery. The formula group reported averaging 32 more minutes of sleep than the breastfeeding group before pregnancy, 33 more minutes during pregnancy, and 24 more minutes post-partum. The formula group had greater variability at all three time points by self report. Both groups estimated slightly more sleep before pregnancy

than during the pregnancy and less sleep since the birth of the baby (see Tables 13 & 14). The number of times that participants got up during the night before, during, and after the pregnancy also were recorded and a greater amount of awakenings were reported by the breastfeeding group at all three time points by self report.

Table 13

Estimated Sleep by Self-Report Before, During and after Pregnancy

Characteristic-Amount of Sleep And Sleep interruptions	Total N= 44	Breast n=22	Formula n= 22
Estimated amount of sleep (in minutes)			
Before pregnancy			
Range	360-600	360-540	390-600
Mean (SD)	479(53)	464(45)	496(58)
During pregnancy			
Range	240-720	360-570	240-720
Mean(SD)	474(109)	457(74)	490(136)
Since delivery			
Range	240-570	240-420	240-570
Mean(SD)	334(66)	322 (45)	346(82)
Interruptions (frequency)			
Before Pregnancy			
Range	0-2	0-2	0-1
Mean (SD)	.28 (.53)	.32(.63)	.24(.43)
During Pregnancy			
Range	.5-7	.5-5	1-7
Mean(SD)	2.88(1.4)	3.1 (1.2)	2.6(1.5)
Since Delivery			
Range	1-5.5	1.5-5.5	1-5
Mean(SD)	2.94(1.1)	3.14(1.1)	2.75(1.1)

On the first night of the study when the wrist actigraphy was applied, the investigator did a "Practice" St.Mary's Hospital Sleep Questionnaire regarding the previous night's sleep. The

participants then recorded their sleep patterns and amounts each night of the study. There was no statistically significant difference between nights or by group in the self report of sleep time or sleep interruptions when examined by t-test.

Total sleep time and sleep interruptions were recorded with polysomnography, wrist actigraphy and self report. Participants reported between 2-3 awakenings per night (see Table 13 and 14). The most common reason (95%) for awakening, as indicated by responses to questions on the SMHSQ, was feeding of the baby. The other 5% of reasons for awakenings were reported as restlessness, dogs barking, unsure why awake, or going to the bathroom.

Table 14

Total Sleep Time and Sleep Interruptions by Self-Report

Characteristics	Total N= 44	Breast n=22	Formula n= 22
Total Sleep Time from St. Mary's Sleep Questionnaire			
Practice Night			
Range	120-570	235-495	120-570
Mean(SD)	350(92)	367(71)	333(108)
Night 1			
Range	240-555	300-555	240-540
Mean(SD)	397(67)	407(71)	386(64)
Night 2 (PSG night)			
Range	120-480	120-480	210-480
Mean(SD)	379(76)	376(81)	383(72)
Night 3			
Range	240-630	270-545	240-630
Mean (SD)	408(84)	411(80)	405(91)
Total Sleep Interruptions from St. Mary's Questionnaire			
Practice Night			
Range	0-6	0-6	0-5
Mean(SD)	2.4(1.3)	2.6(1.4)	2.3(1.1)

Table 15 (continued)

Night 1			
Range	1-6	1-6	1-5
Mean(SD)	2.98(1.3)	3.3(1.5)	2.6(1.1)

Night 2 (PSG night)			
Range	1-6	1-5	1-6
Mean(SD)	2.61(1.3)	2.7(1.3)	2.6(1.4)
Night 3			
Range	0-7	1-7	0-5
Mean(SD)	2.56(1.4)	2.9(1.3)	2.2(1.3)

Other Factors That Might Influence Night-Time Sleep

Twenty of the subjects did not nap during the data collection period, with twelve of the formula group never napping compared to eight of the breastfeeding group (see Table 15). A fourth of the participants, who napped, only did so once, with only two of the breastfeeding participants napping at all during the four time periods and none in the formula group. T-tests were conducted to see if there was a difference in total sleep time the night of napping or if a nap occurred the next day and no differences were found in sleep based on napping.

Table 15

St. Mary's Hospital Sleep Questionnaire Napping

Characteristic Napping	Total N= 44	Breast n=22	Formula n= 22
Napping on previous day			
Practice Night	12 (27%)	10 (45%)	2 (9%)
Night 1	9 (20%)	5 (23%)	4 (18%)
Night 2	10 (23%)	6 (27%)	4 (18%)
Night 3	17 (39%)	8 (36%)	9 (41%)
Did not nap at all	20(45%)	8 (36%)	12 (54%)
Napping only one day	11 (25%)	6 (27%)	5 (23%)

Table 15 (continued)

Napping two Days	5 (11%)	3 (14%)	2 (9%)
Napping three days	6 (14%)	3 (14%)	3 (14%)

Napping all four days	2 (5%)	2 (9%)	0 (0%)

The subjective ranking of satisfaction with sleep, the depth of sleep obtained, the difficulty getting to sleep and how clear headed the participant felt upon awakening were reported by self report (see Table 16). The mode selection for sleep depth was "average-deep" in both groups with the first night having "light-average" selected more frequently. For the subjective measure of "How well did you sleep last night"- "fairly well" was the mode on all four collection points. How "clear-headed" the subjects felt upon arising was rated "fairly clear headed" to "alert" most commonly. For the subjective measure of "satisfaction" with the night's sleep "fairly satisfied" was the mode selection across all four time points. "None to very little" was the most common selection for the question about "difficulty getting off to sleep" with only two participants expressing extreme difficulty in getting to sleep on one of the nights. No significant differences were noted between groups.

Table 16

St. Mary's Hospital Sleep Questionnaire Perception of Sleep

Variable	Total N= 44	Breast n=22	Formula n= 22
Rating of sleep depth (1-8)			
Practice Night			
Range	2-7	2-7	3-6
Mean (SD)	4.3(1.2)	4.5 (1.5)	4.1(.9)
Night 1			
Range	2-8	2-7	2-8
Mean (SD)	4.5(1.3)	4.7(1.3)	4.3(1.4)

Table 16 (continued)

Night 2			
Range	2-8	2-8	3-8
Mean (SD)	4.8(1.3)	4.8(1.4)	4.9(1.2)
Night 3			

Range	2-8	2-8	3-7
Mean (SD)	4.8(1.1)	4.9(1.3)	4.7(.9)

Sleep Quality (possible range of 1-6)

Practice Night			
Range	2-6	2-6	3-5
Mean(SD)	4.1(.87)	4.2 (1.0)	3.9(.68)
Night 1			
Range	2-6	2-6	2-6
Mean (SD)	3.9(1.0)	3.90(1.1)	3.95(.95)
Night 2			
Range	1-6	2-6	1-6
Mean (SD)	4(1.1)	4.1(1.2)	3.9(.94)
Night 3			
Range	2-6	2-6	3-6
Mean (SD)	4.2(.97)	4.2(1.06)	4.2(.87)

Drowsy to Alert (possible range 1-6)

Practice Night			
Range	1-6	1-6	1-6
Mean (SD)	3.7(1.3)	3.7(1.3)	3.8(1.4)
Night 1			
Range	1-6	2-6	1-6
Mean(SD)	4.0(1.0)	4.0(1.0)	4.1(1.1)
Night 2			
Range	1-5	1-5	3-5
Mean (SD)	4.1(.83)	4(1.02)	4.1(.61)
Night 3			
Range	1-6	1-6	3-6
Mean (SD)	4.1(1.1)	4.1(1.2)	4.1(.99)

Sleep Satisfaction (possible range 1-5)

Practice Night			
Range	1-5	1-5	1-5
Mean(SD)	3.6(.93)	3.6(1.0)	3.6(1.0)

Table 16 (continued)

Night 1			
Range	1-5	1-5	2-4
Mean (SD)	3.5(.88)	3.4(1.1)	3.6(.59)
Night 2			

	Range	1-5	1-5	1-4
	Mean (SD)	3.4(.95)	3.5(1.01)	3.3(.89)
Night 3				
	Range	1-5	1-5	1-5
	Mean (SD)	3.7(.94)	3.64(1.0)	3.76(.89)

Difficulty getting to sleep (possible range of 1-4)

Practice Night				
	Range	1-4	1-3	1-4
	Mean (SD)	1.32(.67)	1.27(.55)	1.36(.79)
Night 1				
	Range	1-3	1-2	1-3
	Mean (SD)	1.32(.56)	1.23 (.43)	1.41(.67)
Night 2				
	Range	1-4	1-3	1-4
	Mean (SD)	1.5(.76)	1.55(.74)	1.45(.80)
Night 3				
	Range	1-3	1-2	1-3
	Mean (SD)	1.39(.58)	1.23(.43)	1.57(.68)

Time in Bed

By self report, the participants went to bed between 8pm and 3am and got up between 3:15 am and 1:30 pm, a wide range of bed times. The average time for bed was between 10-11pm and the average time to get out of bed was between 8-9am. There was more variance in the formula feeding group with a wider range of bed times and times for awakenings. However there was no statistical difference between groups on these sleep measures (See Table 17). The time it took to get to sleep was greater in the formula group by about 10-15 minutes, but did not reach a level of significance when compared using a t-test.

Table 17

St. Mary's Hospital Sleep Questionnaire Bedtime Parameters

Characteristic	Timing	Total N= 44	Breast n=22	Formula n= 22

Time participant went to bed				
	Range			
	Practice Night	8p-3a	9p-2am	8p-3a
	Night 1	8:30p-2a	9p-MN	8:30p-2a
	Night 2	8:50p-1:30a	9:05p-0:15a	8:50p-1:30a
	Night 3	8:50p-1:45a	9:25p-1:30a	8:50p-1:45a
Time participant got up and out of bed				
	Range			
	Practice Night	3:15a-12:30p	6:20-11:00a	3:15a-12:30p
	Night 1	4:05-11:30a	6:30-11:30a	4:05-11:30a
	Night 2	4:30-11:30a	5:25-11:22a	4:30-11:30a
	Night 3	5:00a-1:30p	7:00-11:45a	5:00a-1:30p
Time in Bed (minutes)				
	Practice Night			
	Range	300-810	330-780	300-810
	Mean(SD)	548(122)	570(119)	527(124)
	Night 1			
	Range	410-855	480-840	410-855
	Mean(SD)	618(90)	633(89)	602(90)
	Night 2			
	Range	375-832	375-832	390-810
	Mean (SD)	559(106)	548(106)	570(107)
	Night 3			
	Range	330-840	420-795	330-840
	Mean(SD)	583(113)	594(102)	572(124)
Sleep latency				
	Practice Night			
	Range	1-240	1-120	1-240
	Mean(SD)	29(40)	24(27)	35(50)
	Night 1			
	Range	0-165	5-75	0-165
	Mean(SD)	28(26)	22(16)	33(33)
	Night 2			
	Range	1-120	5-60	1-120
	Mean(SD)	30(25)	23(14)	36(31)
	Night 3			
	Range	1-150	5-140	1-150
	Mean(SD)	30(34)	23(28)	38(39)

Additional Considerations

There were a very small number of women who reported they were not the primary caretaker of the baby and all of them were in the formula-feeding group. There was no difference

between those participants who reported being the primary caretaker and those who did not on the sleep parameters when analyzed with a MANCOVA, equal variance not assumed.

Another factor that has been shown in the first few days postpartum to impact sleep is the method of delivery. Approximately 25% of the sample had cesarean births. Sleep characteristics data was analyzed by delivery method and no difference was found between birth modes using a MANCOVA for sleep architecture and t-test for total sleep time.

Comparison of Results by Measurement Tool

The only differences found were related to the tools for measurement of sleep. Although there were high correlations between the tools used to measure sleep which all reached a level of significance, the actual recordings of the number of minutes of sleep were different between tools across both groups. There was a statistical difference shown in a paired t-test between the wrist actigraphy and polysomnography ($t = 4.06$, (39), $p=.000$), which was significant for the whole group and by subgroups of breastfeeding ($t=3.31$, (19), $p = .004$) or formula-feeding ($t=2.38$, (19), $p= .028$). Wrist actigraphy recorded more sleep than polysomnography. Self – report and wrist actigraphy also were significantly different for the whole group ($t=-3.42$, (39), $p=.001$) and by subgroup of breastfeeding ($t=-2.88$, (19), $p=.010$) or formula-feeding ($t=-2.40$, (19), $p=.027$). Differences between the St. Mary's Hospital Sleep Questionnaire (self report) and polysomnography testing were not statistically significant for either group (See Table 18).

Table 18

Comparison of Total Sleep Time by St. Mary's Sleep Questionnaire, Wrist Actigraphy (WA) and Polysomnography (PSG) for those subjects with complete data sets

Paired t-tests				
Tool	Mean (SD)	t	df	p

Total group N=40				
WA	416.4 (65.6)	4.06	39	< .001
PSG	396.8 (73)			
Self Report	380.3 (64.7)	-3.42	39	.001
WA	416.4 (65.6)			
Self Report	380.3 (64.7)	-1.44	39	.159
PSG	396.8 (73)			
Breastfeeding n=20				
WA	412.7 (57.1)	3.31	19	.004
PSG	389.3 (61.2)			
Self Report	386.3(60.2)	-2.88	19	.010
WA	412.7 (57.1)			
Self Report	386.3(60.2)	-.33	19	.742
PSG	389.3 (61.2)			
Formula n=20				
WA	420.2 (74.4)	2.38	19	.028
PSG	404.3 (84.1)			
Self Report	374.3 (69.9)	-2.40	19	.027 .
WA	420.2 (74.4)			
Self Report	374.3 (69.9)	-1.43	19	.169
PSG	404.3 (84.1)			

Summary

This chapter provided the summary of the study results for this group of 44 participants who were new mothers. The only statistically significant differences found between groups were level of education and nicotine use. Sleep characteristics were not found to be different at a level of statistical significance between breastfeeding or formula-feeding mothers when controlling for nicotine, age or education level. The wrist actigraphy and home polysomnography were statistically different in the measurement of total sleep time. The mothers self-report was close to

the gold standard measure of PSG with no statistical difference between their report and the PSG. The formula group had greater variance on most parameters measured, such as time to bed, time in bed, amount of sleep, and scores on the Edinburgh for the week prior to the sleep monitoring. The subjective measures of sleep were similar across the four nights and between groups.

Chapter V

DISCUSSION OF FINDINGS

Introduction

This comparative prospective study was conducted to describe and compare the sleep architecture of twenty-two breastfeeding and twenty-two formula-feeding mothers between the fourth and sixth weeks postpartum. This study was a systematic replication and extension study of a study by Blyton, Edward, and Sullivan (2003) that concluded that 12 breastfeeding mothers obtained a statistically significant increase in slow wave sleep when compared to a group of 7 formula-feeding and 12 non-pregnant, non-lactating women. This finding was not supported by the results of the current study. The time frame of data collection, size of the sample and other variables were more tightly controlled in this current study. Lee's Model of Impaired Sleep (Lee, 2003) guided the study with the explanation that role demands, hormonal influences and a baby requiring feeding, impact the sleep of new mothers. The results of the study, the comparison of the finding to the review of the literature, as well as methodological issues and implications for future research and practice, will be discussed in this chapter.

Summary of Findings

Research Question One

What are the differences in sleep architecture characteristics including total sleep time (TST), light sleep (N1, N2), deep sleep (N3,4), REM sleep and number of awakenings after sleep onset and wake time after sleep onset between breastfeeding (fully lactating) and formula feeding mothers at four to six weeks postpartum?

There were no statistically significant differences found in the sleep architecture characteristics in this sample of breastfeeding and formula feeding mothers from four through six

weeks postpartum. There was a wide variance on most sleep parameters measured in both groups, however that variance was more pronounced in the formula-feeding group. In spite of this, there were no significant differences noted on any of the sleep characteristics of total sleep time, stages of light sleep, deep sleep, REM or wake after sleep onset between groups.

The one sleep architecture characteristic which was closest to reaching a level of significance and which had a partial eta squared = 0.136, was REM sleep. REM sleep was slightly higher in the formula feeding group. REM sleep is greater in younger women, and given the increased number of younger women in the formula-feeding group this was not surprising (Lee, as cited in Carrieri-Kohlman, Lindsey, & West, 2004). Slow wave sleep deep sleep was not significantly different between groups, although there was a slightly higher percentage found in the breastfeeding group and a slightly lower percentage of light stage 2 sleep in this group.

Research Question Two

What are the sleep characteristics and self-reported descriptions and perceptions of sleep in breastfeeding (fully lactating) and formula-feeding mothers at four through six weeks postpartum?

Individual differences within the groups were greater among those formula-feeding. Breastfeeding mothers perhaps are more into a routine since the night-time feeding is primarily their responsibility. The possibility of someone else providing more care for the baby on one night than another would seem more likely in the formula-feeding group perhaps accounting for this lack of stability across days.

The formula-feeding group self-reported more sleep prenatally (by 32 minutes), during pregnancy (by 33 minutes) and postpartum (by 24 minutes) than those who were breastfeeding. Both groups reported less overall sleep during the postpartum period than they normally had

prenatally; 150 fewer minutes in the formula-feeding group and 142 fewer minutes in the breastfeeding group. The formula feeding group obtained a mean of 390 minutes (6.5 hours) by self-report, 420 minutes (7 hours) by wrist actigraphy, and 404 minutes (6.7 hours) by home polysomnography. The breastfeeding group obtained a mean of 398 minutes (6.6 hours) by self-report, 412 minutes (6.9 hours) by wrist actigraphy, and 389 minutes (6.5 hours) by polysomnography. Except for by self-report, the breastfeeding group reported slightly less sleep than the formula-feeding group, similar to their self-reported estimates before the data collection began of less sleep obtained by the breastfeeding group. Total sleep time was not found to be significantly different; nor was there a clinically meaningful difference .

The breastfeeding group reported more exercise prior to data collection, but there was no difference in amount of exercise noted on the three nights of data collection. Many moms mentioned that they were hoping to get back into exercise, so perhaps the intention to exercise was greater in the breastfeeding group.

Naps were not taken by twelve of the formula feeding mothers and eight of the breastfeeding group. Only two mothers in the breastfeeding group napped on all data collection days and none in the formula feeding group.

Sleep depth, quality of sleep, drowsiness upon arousal, sleep satisfaction and difficulty getting to sleep were recorded and very similar between groups. The night of the polysomnography had the potential to impact the perception of sleep given the application of electrodes to the scalp and the need for a recording box to be attached to the participant. However this night was not found to be different by wrist actigraphy or self-report than on any of the other nights.

The formula-feeding group had a wider range of time to bed, time in bed, and time it took for fall asleep (sleep latency). The formula-feeding group had a mean of 35.5 minutes to fall asleep compared to 23 minutes in the breastfeeding group. This difference may have been related to nicotine consumption which can be a stimulant if consumed immediately prior to sleep.

Study Findings in the Context of Extant Knowledge

Blyton, Sullivan and Edwards (2002) used a convenience sample of women 19-39 years of age with infant ages of 4-30 weeks for the twelve breastfeeding subjects and 22-38 maternal age for the seven formula-feeding subjects with infants age 6-28 weeks. They also had 12 non-pregnant and non-lactating women matched for age and BMI with the breastfeeding mothers. There was no mention of whether or not the mothers in their study had help at home during the night, this factor could influence the amount or depth of sleep obtained.

The mothers in their study were questioned about the quality and length of their sleep on the night before the polysomnography, the data on quality was not provided, the mothers reported a mean of seven hours of sleep the night before in each group. A difference from the current study was that none of the mothers reported napping on the day before the study was completed. The mothers in their study averaged 7.5 hours of sleep for the control group and 7 hours for the breastfeeding and formula feeding group. This slight increase above the current study may be related to the wide range of infant ages in the Blyton, Sullivan and Edwards (2002) study which was conducted across the time when infants begin to chain together sleep cycles and start sleeping through the night. Sleep efficiency in the Blyton et al (2002) study ranged from 86% in the breastfeeding group to 93% in the formula-feeding group and 95% in the control group. Sleep efficiency was lower in the current study, and similar for both the breastfeeding group (74%) and formula-feeding group (72.5%). This is most likely related to the sleep patterns

of the infant who required 2-3 sleep interludes at 4-6 weeks postpartum for feeding and optimal growth. There was not a significant difference regarding wake time after sleep onset between the two groups.

The polysomnography recordings in the Blyton, Sullivan, and Edwards (2002) study were done in a similar manner to the current study. They found that the breastfeeding subjects were more likely to have SWS deep sleep during the second half of the night. We did not evaluate whether the SWS was found in the beginning or end of the night of sleep. We did find that the participants who had larger amounts of SWS (above 20% of the night) had lower percentages of light sleep, N1 and N2, consistent with Blyton, Sullivan, and Edwards (2002). They also found a significantly lower arousal index in the lactating group than the controls or formula-feeding mothers, there was no difference between groups on this variable in the current sample.

Blyton, Sullivan and Edwards (2002) did not report what day of the week the study was conducted. If these mothers had been working all week, slept "normally" on Friday night and then were studied on Saturday they may have been having recovery sleep. In addition infant sleep patterns can vary when they are experiencing developmental growth spurts (Barnard, 1999) all more likely to occur when a study is completed with infants at varying ages.

Nishihara and Horiuchi (2004) studied ten first time mothers with home polysomnography compared with a group of non-pregnant, non-lactating women and found no differences in sleep architecture except for delayed sleep onset in the lactating group. They found that 80% of the mothers were satisfied with their sleep, their findings were confirmed with this current study where over 70% reported being fairly satisfied to very satisfied and 80% reported sleeping fairly well to very well. In addition in the current study both groups of new mothers had

a greater sleep latency (time to get to sleep) than what is expected for the average adult (5-15 minutes). Nishihara and Horiuchi (2004) suggested that we reword the term "post-partum sleep deprivation" to "maternally acceptable sleep." This change in viewpoint about the language we use to describe postpartum sleep was support by James McKenna (personal communication, 2005) when he and I concluded that we should rename "sleep interruptions" as "night time sleep interludes" in order to make it a part of the normal postpartum sleep experience.

The review of the literature for this study on maternal sleep and the relationship to feeding method revealed inconsistent findings. Wright, Fawcett, and Crow (1980) reported fewer sleep interruptions in the formula-feeding mothers, this was not found in this current study. Alley and Rogers (1986) found that there was no difference in the number of infant feeding between breastfeeding and formula-feeding dyads which was consistent with the findings of this study.

The range of sleep was 4.1-9.2 hours by both wrist actigraphy and polysomnography with a mean of 6.4 by polysomnography and 7 by wrist actigraphy in the current study, this is consistent with the findings of Quillin (1997) who reported 6.15 hours of sleep by self report at four weeks post-partum, and Signal et al.(2007) reported a mean of 7.29 hours at 6-7 weeks with a range of 4.37-9.27 hours.

Infant sleep environment findings were similar to literature as well. Willinger et al. (2003) reported that at 4 months of age 44.7% of infants spent some time in the parental bed and 12.8% routinely bed shared. Glenn and Quillin (2007) reported that 51% spent some of the night in the parental bed. In this current study 50% of the babies spent some time in the parental bed and 30% routinely bed shared at 4-6 weeks post-partum. The mothers reported before data collection that only 14% routinely bed shared, but on the practice night and the three nights of data collection 30% actually slept in the mother's bed.

There was no difference in the current study between those who delivered by cesarean section and those who delivered vaginally at 4-6 weeks postpartum. Lee and Lee (2007) had found more sleep in vaginally delivered mothers during the first week post-partum. This difference may diminish as the pain from surgery diminishes by the 2-3 week postpartum.

Interpretation Summary

The current study of first time mothers 4-6 weeks post-partum did not demonstrate any significant differences in sleep architecture characteristics or descriptions and perceptions of sleep between equal sized groups of breastfeeding and formula-feeding mothers. The results of Blyton, Sullivan and Edwards (2002) were not replicated. The difference in the time frame of the studies and the limitation to first time mothers may account for the difference. They may have had a group of women who were very sleep deprived in the breastfeeding group or were recovering with an increase in SWS. Infants who are four weeks of age have very different sleep patterns than those who are 28-30 weeks, or 7 months of age, and who are most likely sleeping through the night. If the subjects in the Blyton et al. study had other children at home, those responsibilities may have added to the possibility of obtaining "rebound" or "recovery" SWS on the night that the study was done. The study being replicated also did not report any concurrent validity testing done with self-reports or wrist actigraphy to observe if there was a correlation between the tools regarding in the sleep pattern of that night. No subjective measure of sleep was used to assess if the night of the study was different for the mother from the previous night when they reported satisfaction and 7 hours of sleep.

What was reinforced with the data obtained from this study is the fact that new mothers have a wide variety of postpartum sleep patterns and that they vary within the groups of breastfeeding and formula-feeding and vary individually from night to night. Although consistent

sleep patterns are desirable for optimal sleep hygiene, many adults experience differences in their hours of sleep and number of sleep interludes from night to night.

The amount of sleep in minutes recorded on the St.Mary's Hospital Sleep Questionnaire, the wrist actigraphy and the home polysomnography were compared. A surprising finding was revealed. Traditionally self-report has been identified as the least reliable measurement tool, however there were no statistically significant differences between self-report and polysomnography in either group. The wrist actigraphy and polysomnography were found to be significantly different. The wrist actigraphy detects movement in the non-dominant wrist and lack of movement is recorded and interpreted as sleep. PSG detects actual brain waves which reflect sleep and wake states most precisely. New mothers, who are awakened 95% of the time to feed a baby, might be drowsy (not sleeping) and not moving while feeding their baby. Breastfeeding mothers might be less likely to move during this drowsy phase as they are not preparing, moving a bottle, or burping as frequently as a formula-feeding mother might be doing. Traditionally the sleep in new mothers is measured by wrist actigraphy. This study raises serious questions about validity and accuracy of this measurement approach. In this study, wrist actigraphy led to significantly different amounts of sleep from self-report or polysomnography. This suggests wrist actigraphy over reports the amount of sleep obtained.

Implications for Practice

This research can assist lactation consultants and maternal-child health care practitioners who often are faced with patients who report the lack of initiation or the desire to stop breastfeeding in order to obtain more sleep. It can be reported that in this convenience sample of first time breastfeeding and formula-feeding mothers there was not a statistically significant difference in the amount of total sleep or sleep interruptions based on feeding method. The

results of this study could lead the practitioner to say that sleep varies from person to person and there are many factors that influence the amount of sleep obtained. New mothers tend to sleep less than they did prenatally or during pregnancy and are frequently interrupted. Strategies for sleep hygiene explored in Stremler et al. (2007) would be useful for new mothers. The amount of sleep and number of interruptions in this group of demographically similar mothers was not dependent on feeding method in this particular study. This alone cannot guide the advice that practitioners give, but it does add to the body of knowledge related to the sleep difference or lack of difference in breastfeeding and formula-feeding mother.

The mothers in the study were curious and concerned about sleep consistent with the findings of So, et al. (2005) and Doan, et al, (2007). Across both groups they expressed concern about the number of interruptions of sleep they were experiencing and the desire to have uninterrupted sleep. Information on maternal and infant sleep and typical patterns and time frames as well as education on sleep hygiene was provided to the mothers with their sleep results after their data was analyzed.

The fact that the participants reported on the demographic profile that only 14% of their babies slept in their parents bed, but on the self-report tool, SMHSQ over 30% of the babies actually slept in the parents' bed at all 4 data collection points is important information for practitioners. Parents are instructed and the American Academy of Pediatrics reinforces that babies should sleep in the parents room, but not in the same bed. Parents perhaps answered this question as they knew they should, but in reality, and perhaps out of an effort to obtain more sleep, they did not practice what they initially reported. Health care practitioners need to be aware of this and realize that in this study, consistent with the literature, over 50% of the babies

spent some time in the parent bed. This begs for more education about safe sleep habits to be discussed and reinforced at each visit with new families.

This study showed no significant difference between the mothers' self-report of total sleep time and that of the home polysomnography. This information could be used by practitioners to feel confident in using sleep diaries with new moms to get an approximation of what is actually happening at night. The SMHSQ is a quick easy tool to use to assess the maternal perceptions of sleep. Practitioners could also assure mothers that they know approximately how much sleep they are getting and should nap on the days that they did not obtain an appropriate amount of sleep.

Implications for Research

The differences found in the tools used to measure sleep needs to be explored. In this study self report and polysomnography were not significantly different. PSG is the "gold standard" for measurement of sleep and yet the majority of studies in new mothers used wrist actigraphy or subjective reports for total sleep time measurement. There was a statistically significant difference between wrist actigraphy and home polysomnography. A video recording of the mothers sleeping and caring for their infant with wrist actigraphy might shed some insight into the potential for the wrist actigraphy to report as sleep quiet feeding times. The correlation between the polysomnography and wrist actigraphy was very high r =.91), suggesting that something consistent across subjects was happening that caused the over-reporting of sleep by wrist actigraphy. Given that the mean of sleep interludes was 2.5 per night in each group, and 95% of the interruptions were reported as infant feeding, it seems most logically the reason for the difference. The wake after sleep onset mean was two hours with a range from 14 minutes to a little over 5 hour reflective of the range of sleep interludes from zero to six. The

polysomnographic technician and primary investigator could do a minute by minute comparison of the wrist actigraphy and polysomnography to see if sleep recorded by wrist actigraphy corresponds to wake or sleep in the polysomnography. This would have implications for researchers who utilize wrist actigraphy to report on average amount of sleep in new mothers.

This study is one of the larger to date in the use of home polysomnography with post-partum women. The home polysomnographic study required about 2.5 to 3 hours of the new mothers time. Mothers may be more willing to participate if they do not have to stay overnight away from home with their baby in an artificial environment. The equipment was very reliable and easy to use. Cost of doing a home polysomnography could limit the usability in some settings and requires a dedicated computer and flexibility of the researcher in terms of the evening time for application of the leads and commuting to the participant's home. The equipment was donated for the duration of the study and each study cost $50.00 for analysis and recheck. Wrist actigraphy does not have to be read by a polysomngraphic technician and is more user-friendly and cost-effective.

This study should be replicated with teen moms, older first-time mothers, and with those women who have other children in the household to increase the generalizability. Replicating this study at a later postpartum point when mothers may have returned to work could potentially change the outcomes. Lee (1998) reported that most mothers have returned to previous pre-pregnancy sleep patterns by three months postpartum. It would be interesting to replicate the current study at 6 months. Finding mothers who are exclusively breastfeeding at that time point may be more challenging as breastfeeding rates drop after 3 months post-partum. Once moms have returned to work, finding the best time to observe a "typical" night of sleep may be challenging.

Assumptions for this study

The assumption that post-partum women have changes in their sleep patterns was confirmed. The amount of sleep that both the breastfeeding and formula feeding groups self-reported was less during the post-partum period than before or during the pregnancy. This was consistent in both groups. The second assumption was that sleep loss would be associated with infant feeding method. This was found to be true in this study as 95% of the sleep interruptions reported by the mothers in both groups were related to infant feeding regardless of feeding method. The third assumption was that the research procedures using home polysomnography, self-report tools and wrist actigraphy would not overly burden the new mother or significantly change her sleep pattern. There was only one mother who declined to have the home polysomnography related to concern about having to wet her hair. No mother withdrew after beginning the study and the perceptions of sleep quality or satisfaction were not significantly different across the three nights of sleep. The fourth assumption was that there would be differences in breastfeeding and formula-feeding mothers demographically. This assumption was confirmed with a significant difference in level of education and nicotine use as well as more variance in the level of income and age in the formula-feeding group.

Limitations and Strengths

This study was limited to a convenience sample of first time mothers who had not returned to work outside the home and were living with another adult. It was difficult to recruit formula feeding mothers in the community where the study was conducted as the initiation rate of breastfeeding is 90% for first time mothers. Three women in the formula-feeding group were initially breastfeeding their babies, but chose to quit at two weeks for a variety of reasons. One mother ceased because of breastfeeding challenges, one participant wanted to be ready to return

to work, and one because the baby did not "tolerate" her milk. Although none of these mothers had put the baby to the breast for over 2-3 weeks, thereby reducing the potential influence of prolactin which typically returns to normal levels within 1-2 weeks after weaning (Lawrence & Lawrence, 2005) , it would have been ideal to have only those who exclusively formula-fed from the beginning in that group.

The fact that the mothers in this study were all first time mothers helped reduce the variability of the responsibilities that having other children may have had on sleep. However, first time mothers are learning about being a mother, about breastfeeding, and may be more anxious. This could have had an influence on their sleep patterns and impacted their ability to fall into deep, slow wave sleep. If experienced mothers had been included, we would have diminished the impact that learning about breastfeeding and babies might have had on breastfeeding mothers sleep patterns thus increasing generalizability to the postpartum period.

In the original planning of the study design, only those who had delivered vaginally were going to be used in the sample, however it was discovered that one mother had had a cesarean birth after data collection had occurred. This change was discussed with some members of the committee and it was decided that a representative sample (reflective of the rate of cesarean birth in the community) of cesarean birth mothers would actually strengthen the study. Thus, a change in the sampling criteria was submitted to the IRB for approval and allowed both modes of births in the study sample. Ultimately, no difference was found in sleep characteristics related to delivery method.

Another potential limitation of the study, was that mothers who were willing to have someone come into their home and physically apply lead wires to their head may have been mothers who have a certain level of comfort with their adjustment to parenthood. The mothers in

this study did not have any variance on the questions ; “The thought of harming myself has occurred to me” all mother’s answering “never” and “ I have looked forward with enjoyment to things” all mother’s answering, “as much as I ever have”. This may explain the slightly lower reliability rating of the depression scale with no mothers varying on those two questions. The mothers who would have rated higher on the depression scale may have been more likely to decline to participate. Therefore we can only generalize findings to first time mothers who are not demonstrating any signs or symptoms of depression. Given the relationship between depression and fatigue or sleep disturbance, this eliminates generalizability to women who are depressed.

In hindsight, a questionnaire on sleep hygiene may have been helpful. Knowing more about the sleep environment, such as use of a TV or computer right before bed or typical bedtime and wake time beyond just the day before the study started might have offered insight into variance in the sleep patterns. In addition, more details about “normal” patterns of sleep for the participants, such as meal times, routines for bathing or reading or relaxation before sleep. The participant’s view about the night routine would have been interesting as well, such as a feeding schedule for the baby versus on demand. It would have been interesting to observe if those who stated that they were on a schedule actually had more consistency in their sleep patterns than those who followed the baby’s lead. Information about whether or not they had read any information about infant and post-partum sleep in terms of establishing patterns and routines for bed time would have added to this study as well.

There were a variety of “other adults” in the household. Only three of the mothers reported that they were not the primary caretaker of the baby. There was no difference noted in their sleep patterns to a level of significance when conducting a MANCOVA, equal variances

not assumed on the sleep characteristics. A limitation of the study was not asking for specific details about who got up with the baby. Mothers may have reported that their sleep interlude was related to baby feeding, but specific details of what they did were not obtained. In addition it would have been easy enough and interesting to have the "other adult" wear a wrist actigraphy and a comparison of their sleep to the new mothers sleep could have been done. This would require another research study.

A major strength of the study was the consistency of research personnel. The primary investigator and two research assistants were trained for the application of the electrodes to the scalp and face. In actuality the primary investigator applied all electrodes and conducted each of the polysomnography studies, diminishing any variance related to the methods used. In addition, the same polysomnography technician, who has 22 years of experience, read and scored all of the PSG sleep data while blinded to whether the woman was in the breastfeeding or formula feeding group. The same technician also re-checked all of the studies for arousal scoring and there was a high level of concordance. Also, all data were entered by the primary investigator and a research assistant double-checked all data entry for accuracy and any errors were re-checked by a third researcher to verify accuracy. All of these consistencies reduced measurement error and increased reliability of the data.

Another strength of the study was the control of extraneous variables that could impact sleep. By controlling for maternal and infant age, parity, gestational age, infant weight, work status, living situation, medication use, and history of sleep disorders, a more homogeneous sample was obtained. This may have had an impact on the findings by reducing variance in the outcome variables.

Conclusions

Sleep is a major concern of new mothers and in spite of all the other adjustments they are going through, new mothers were willing to take 5 hours of their time and be connected to a home polysomnography in order to find out more about their sleep or lack of sleep. This systematic replication study of first time mothers from 4-6 weeks postpartum did not yield the same findings of the original study. Sleep architecture characteristics in this sample of breastfeeding and formula-feeding mothers were not significantly different. This finding is also different from what is generally described in lay literature and media, as well as what many health professionals describe. Sleep is unique to the individual and varies from night to night.

What was found was a demographic difference between breastfeeding and formula-feeding mothers on the variables of educational level and nicotine use and less consistency in sleep patterns and characteristics in the formula-feeding group. The most surprising finding was a statistically significant difference in the measurement tools of wrist actigraphy and home polysomnography which should be explored in future studies.

Sleep is vital to survival and quality of life, as a new mother's sleep is in a state of change with night time interludes necessitated by a new baby. Trying to navigate this myriad of changes and new experiences, new mothers need factual information and guidance to help them to adapt and respond to the differences as well as guideposts to understand the duration of these changes. This research provides some additional insights into the sleep characteristics, descriptions and perceptions of sleep in breastfeeding and formula-feeding first time mothers during the fourth to sixth week post-partum.

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Appendix A

Letters of Support

These are with the original HSC Proposal

Stormont-Vail HealthCare. The Birthplace/ BreastfeedingFollow up Clinic

St. Francis Health Center. The NewLife Center First Days Clinic and Breastfeeding Resource Center

Shawnee County Health Agency and Miami County Health Department-WIC offices

Pulmonary and Sleep Associates

Stormont-Vail Health*Care* – Maternal/Fetal Medicine offices

Appendix B

Study Poster

New Mothers and Sleep Patterns

Would you like to be a part of a **Research Study** about
NEW MOTHERS and their **SLEEP PATTERNS**
At
One Month
After the Birth of Your BABY?

Are YOU:
*A first time mother?
*Between the ages of 20 and 37?
*Do you live with another adult?
*Was your baby born after 37 weeks of pregnancy?

Then YOU:
May be interested in participating in a research study on new mothers' sleep time and patterns.

***Would you wear a wrist band to measure your sleep and complete a sleep questionnaire for 3 days during the 4th or 5th week after delivery?**

***Would you participate in recording your sleep for at least 1 night?**

Ask your nurse for an information letter with details.
Or
Contact Libby Rosen, RN, Doctoral Candidate 785-845-3731.

Appendix C

Information Letter

Dear Potential Study Participant,

I am a doctoral candidate in the PhD program at the University of Kansas School of Nursing. I am interested in maternal sleep and its effect on the adjustment to parenthood. I am doing a study about sleep in the post-birth period from week four to six.

As a first time new mother you are being invited to take part in this research study. The purpose of this study is to measure the amount of sleep obtained for 3 days starting the Monday or Tuesday of week 4 or 5 after you give birth. The study will be used to provide information on the amount and type of sleep mothers get after giving birth. Your participation is completely voluntary and your identity will be protected in the collection and analysis of the data. If at any time you feel that you do not want to continue to take part, you can drop out of the study.

The study will involve three parts. The first will be for you to wear a wrist actigraphy, a tool to measure sleep. It is similar to a wrist watch and will run for the 3 days of the study. The second part is a 22 question sleep questionnaire that you will fill out noting your sleep times as well as reasons for sleep interruptions. The third part will involve having a home polysomnography test on the second or third day of the study. This involves having 12 lead wires placed on your temples, jaw and head and attached to a monitor box. If for some reason the leads become loose or the reading is not gotten, you may be asked to have the home polysomnography connected again the next night.

Some background information about your usual sleep patterns and your baby's birth and your baby's feeding method will be gotten at the time of your agreement to take part. A depression scale will be administered to rule out postpartum depression which might interfere with your sleep. The total amount of time involved in filling out the sleep questionnaire and background information as well as consent forms will be about 1-2 hours. In a pilot study mothers reported that the time spent in study activities was less than 15 minutes per day. The visits to your home by the researcher to explain the wrist actigraphy and set up the study and to have the home polysomnography connected and removed will take approximately 2-3 hours of your time. As a token of our appreciation for participating in this project you will receive a package of diapers. The results of the study will be shared with you at the completion of the study if you wish. The risk in taking part is small but the loss of time for you at an already busy time in your life may be a burden.

Sincerely,

Libby Rosen, RN
Doctoral Student Researcher
785-845-3731

Karen Wambach, RN, PhD
Faculty Mentor
913-588-1639

Ginger Breedlove, CNM
Faculty Mentor
913-588-1641

(Tear off here)

I am interested in having a full explanation of the study and would like to have the researcher call or visit me in the hospital. By requesting more information I am NOT obligated to take part in the study.

Name_____

_____

Hospital Phone number _____Room Number_____

Home/Cell Phone Number_____

Appendix D

Consent Form

CONSENT FORM

Sleep Characteristics in
Breastfeeding and Bottle-Feeding Mothers from 4 to 6 weeks Postpartum
Protocol # 1

You are being asked to join a research study. You are being asked to take part in this study because you will or have recently had a baby. You do not have to participate in this research study. The main purpose of research is to create new knowledge for the benefit of future patients and society in general. Research studies may or may not benefit the people who participate.

Research is voluntary, and you may change your mind at any time. There will be no penalty to you if you decide not to participate, or if you start the study and decide to stop early. Either way, you can still get medical care and services at Stormont-Vail Health*Care*, St. Francis Health Center, the Birth and Women's Center or the Women Infant and Children's (WIC) office.

This consent form explains what you have to do if you are in the study. It also describes the possible risks and benefits. Please read the form carefully and ask as many questions as you need to, before deciding about this research.

You can ask questions now or anytime during the study. The researchers will tell you if they receive any new information that might cause you to change your mind about participating.

This research study will be conducted as a part of a doctoral dissertation at the University of Kansas School of Nursing with the cooperation of Stormont-Vail and St. Francis Health Centers, and the Birth and Women's Center in Topeka, Kansas. Karen Wambach, RN, Ph D, is the faculty advisor and co-principal investigator. Libby Rosen is the PhD candidate co-investigator. Approximately 60 subjects will be enrolled in the study.

BACKGROUND

New mothers experience changes in their sleep following the birth of their babies and these changes and tiredness often are a concerns for them. Some research has shown that mothers differ in their sleep based on how their infant is fed. More research is needed to more carefully describe new mothers' sleep and differences in sleep phases between breast and bottle-feeding mothers during the 4^{th}, 5^{th} and 6^{th} week after giving birth.

PURPOSE

By doing this study, researchers hope to learn more about sleep patterns in new mothers at 4-6weeks after birth. In addition, researchers will explore if there are any differences in the sleep patterns of breastfeeding or bottle-feeding women postpartum (the time after giving birth).

PROCEDURES

If you are eligible and decide to participate in this study, your participation will last from consent

to approximately 7 weeks postpartum with data collection occurring the 4th, 5th or 6th week postpartum for 3 nights of data collection.

- Your participation may start prenatally or while you are still in the hospital or birthing center after delivery, by providing baseline information about yourself, your usual sleep patterns, and your delivery.
- After completing your baseline information, including your address and phone number, you can expect a call during the 2nd to 3rd week to arrange a time for the researcher to come to your home during the 4th, 5th , or 6th week to begin the study activities.
- On the day the study activities begin the researcher will review the study activities with you and have you fill out the postpartum depression survey. The survey includes questions about whether you have been happy, sad, anxious or scared in the last 7 days or if you have thought of hurting yourself. If you are not comfortable answering any of the questions, you may decline from further participation in the study at that time. If you complete the survey, the researcher will score the survey to determine if you are having depression symptoms that need attention by your health care provider.
- If the depression score is at the level that indicates you should be assessed further for depression, the researcher will recommend that you contact your primary care health care provider. If you give the nurse researcher permission she can call the primary care provider for you. Further study activities will not take place should the depression score indicate the need for further health care provider attention because depression can impact sleep.
- If the depression score is acceptable, the research activities will begin and the researcher will instruct you on the use of the sleep questionnaire and the wrist actigraphy.
- You will begin to wear the wrist actigraphy on the first day the researcher comes to visit during your 4th, 5th, or 6th week postpartum for 3 full days and you will keep records using the St. Mary's Hospital Sleep Questionnaire during that time as well.
- The Actiwatch must stay on your wrist 24 hours per day for the number of days directed (3 days or until the home polysomnography is completed). The Actiwatch can be worn while you bathe, swim, wash dishes, or while feeding or caring for your baby. You will wear the watch on the wrist opposite your writing hand for the number of days requested. The Actiwatch is recording the level of your activity throughout the day and night.
- On the middle evening of the study that week the researcher or research assistant will come to your home to connect the home polysomnography - thirteen wire leads attached to your head and connected to a small box that will assess your sleep for one night. If the leads are removed or fall off during the night for any reason, the researcher will ask if you would consent to have an additional night of home polysomnography for data collection. The researchers will come back in the morning when you call to collect the leads and the polysomnography box in order to obtain the information about your sleep for that night.
- The researcher will return to your home and will pick up the wrist actigraphy and sleep questionnaires when the 3 days of study are completed.
- At any time you can withdraw from the study by simply informing the researcher. If you have signed this consent prenatally you will be asked after delivery if you are still interested in participating and will re-sign the consent at that time. The total amount of time anticipated for your taking part in the study is estimated at 3-4 hours; about 30 minutes for the first, third and fourth visits, about 1-2 hours to set up the middle night

sleep study and about 30 minutes to complete the forms about your sleep history and delivery history, as well as the daily sleep logs.

RISKS

There are no known risks to taking part in the study. New mothers are very busy learning their new role as a mother. Taking any time to complete anything besides caring for self and baby may be stressful. The wrist actigraphy can be worn in the shower or anywhere that you would normally go; however it might be irritating to wear it for 3 days straight without taking it off during the study time. If you wish to wear a wrist band over the wrist actigraphy we will supply you with one. Wearing the home polysomnography leads may be distracting; however no risks have been identified in use of this assessment tool.

There may be other risks that have not yet been identified. If any abuse or neglect of mother or baby is noticed the researcher is obligated to report it to the proper authorities.

NEW FINDINGS STATEMENT

You will be informed if any significant new findings develop during the course of the study that may affect your willingness to take part in this study. You may be asked to sign a new consent form if this occurs.

BENEFITS

You will not benefit from this study. It is thought that additional information gained in this research study may be useful in teaching new mothers about changes in their sleep patterns after giving birth.

ALTERNATIVES

Taking part in this study is voluntary. Deciding not to take part will have no effect on the care or services you receive from your health care provider.

COSTS

There are no costs to taking part in the study. The use of the wrist actigraphy and the home polysomnography and the reading of the information received from them will not cost you any money. These costs are covered by the study.

PAYMENT TO SUBJECTS

There will be no payments for taking part in the study, however, when the researcher picks up the wrist actigraphy and home polysomnography at the end of the study you will be given a package of diapers. Small gifts like a baby rattle will be given at each visit. A copy of the wrist actigraphy and polysomnography records will be given to you after the data are downloaded from the collection tools.

IN THE EVENT OF INJURY

If you have a serious side effect or other problem during this study, you should immediately

contact Libby Rosen at 785-845-3731 or 785-235-2733. If it is after 5:00 p.m., a holiday or a weekend, you should call 785-235-2733 first and then 785-845-3731. A member of the research team will decide if you should seek medical treatment.

INSTITUTIONAL DISCLAIMER STATEMENT

If you think you have been harmed as a result of participating in research at the University of Kansas Medical Center (KUMC), you should contact the Director, Human Research Protection Program, Mail Stop #1032, University of Kansas Medical Center, 3901 Rainbow Blvd., Kansas City, KS 66160. Under certain conditions, Kansas state law or the Kansas Tort Claims Act may allow for payment to persons who are injured in research at KUMC.

CONFIDENTIALITY AND PRIVACY AUTHORIZATION

The researchers will protect your information, as required by law. Absolute confidentiality cannot be guaranteed because persons outside the study team may need to look at your study records. The researchers may publish the results of the study. If they do, they will only discuss group results. Your name will not be used in any publication or presentation about the study. By signing this form, you give permission for your health information to be used and disclosed for the purposes of this research study. If you choose not to sign this form, you will not be able to participate in the study.

The researchers will only use and share information that is needed for the study. To do the study, they will collect health information from the study activities and from your medical record. You may be identified by information such as name, address, phone, or other identifiers.

Your study-related health information will be used at Stormont-Vail Regional Health Center and St. Francis Regional Health Center to determine your eligibility to take part in the study.

By agreeing to this research, you are giving your permission for Stormont-Vail Regional Health*Care* and St. Francis Regional Health Center to share your information with Dr. Wambach and her associates at KUMC. Your information may be shared with officials at KUMC who oversee research, including members of the KUMC Human Subjects Committee and other committees and offices that review and monitor research studies. Study records might be reviewed by government officials who oversee research, if a regulatory review takes place. Your permission to use and disclose your health information remains in effect until the study is complete and the results are analyzed. After that time, information that personally identifies you will be removed from the study records. Because Stormont-Vail, St. Francis, and KUMC are required to comply with the HIPAA Privacy regulations, you information will remain protected from re-disclosure.

QUESTIONS

Before you sign this form, Libby Rosen, or other members of the study team should answer all your questions. You can talk to the researchers if you have any more questions, suggestions, concerns or complaints after signing this form. If you have any questions about your rights as a research subject, or if you want to talk with someone who is not involved in the study, you may call the Human Subjects Committee at (913) 588-1240. You may also write the Human Subjects Committee at Mail Stop #1032, University of Kansas Medical Center, 3901 Rainbow Blvd., Kansas City, KS 66160.

SUBJECT RIGHTS AND WITHDRAWAL FROM THE STUDY

You may stop being in the study at any time. Your decision to stop will not prevent you from getting treatment or services at KUMC, Stormont-Vail Regional Health Center or St. Francis Health Center. The entire study may be discontinued for any reason without your consent by the investigator conducting the study.

You have the right to cancel your permission for researchers to use your health information. If you want to cancel your permission, please write to Dr. Karen Wambach. The mailing address is Dr. Karen Wambach, University of Kansas Medical Center, Mailstop 4043, 3901 Rainbow Boulevard, Kansas City, KS 66160. If you cancel permission to use your health information, you will be withdrawn from the study. The research team will stop collecting any additional information about you. The research team may use and share information that was gathered before they received your cancellation.

CONSENT

Dr. Wambach and Libby Rosen RN, or their associates have given you information about this research study. They have explained what will be done and how long it will take. They explained any inconvenience, discomfort or risks that may be experienced during this study.

By signing this form, you say that you freely and voluntarily consent to take part in this research study. You have read the information and had your questions answered. ***You will be given a signed copy of the consent form to keep for your records.***

_____
Print Participant's Name

_____ _____ _____
Signature of Participant Time Date

_____
Print Name of Person Obtaining Consent

_____ _____
Signature of Person Obtaining Consent Date

For women who enrolled in this study before giving birth:
I confirm that I have had a second discussion with the investigators about the requirements of this study, now that I have given birth. I am still interested and willing to participate.

_____ _____
Signature of Participant

Appendix E

St. Mary's Hospital Sleep Questionnaire

St. Mary's Hospital Sleep Questionnaire **ID#_____**

Adapted from Ellis, BW, Johns, MW, Lancaster, R, et al. (1981). Sleep, 4, 93-97

Today's date: ____/____/_____ Age: _____ years

At what time did you:

1. Lay down for the night? _____ o'clock

2. Fall asleep last night? _____

3. Finally wake this morning? _____

4. Get up this morning? _____

5. **Was your sleep… (circle the best answer)**

1	2	3	4	5	6	7	8
Very Light	Light	Fairly Light	Light-average	Average-deep	Fairly deep	Deep	Very Deep

6. **How many times did you wake up? (circle the best answer)**

None 1 2 3 4 5 6 more than 6 times

7. How much sleep did you have **last night**?
   ____ hours and ____ minutes

8. How much sleep did you have **during the day yesterday**?
   ____ hours and ____ minutes

9. **How well did you sleep last night**? **(circle the best answer)**

1	2	3	4	5	6
very badly	badly	fairly badly	fairly well	well	very well

If you **did not** sleep well, what was the trouble? (e.g., restless, etc.)

1. _____

2. _____

3. _____

10. **How clear-headed did you feel after getting up this morning**? **(circle the best)**

1	2	3	4	5	6
Still very Drowsy	Still Moderately Drowsy	Still Slightly Drowsy	Fairly Clear-headed	Alert	Very Alert

11. **How satisfied were you with last night's sleep? (circle the best)**

1	2	3	4	5
Very Unsatisfied	Moderately Unsatisfied	Slightly Unsatisfied	Fairly Satisfied	Completely Satisfied

12. **Were you troubled by waking early and being unable to get off to sleep again**? 1. No 2. Yes

13. **How much difficulty did you have in getting off to sleep last night?**

1	2	3	4
None or Very Little	Some	A Lot	Extreme Difficulty

14. **How long did it take you to fall asleep last night**?
____ hours and ___ minutes

The following questions are being asked due to possible effect on sleep:

15. **Did you have any alcohol yesterday?** 1. Yes 2. No

If yes, how much and when: _____

16. **Did you take any medications in the last 24 hours**?
1. Yes 2. No

If yes, what and when? _____
_____

17. **Did you have exposure to nicotine yesterday, such as smoking cigarettes or chewing tobacco, or nicotine replacement gum or patch?**
1. Yes 2. No

If yes, how much and when? _____
_____

18. **Did you exercise in the last 24 hours?** 1. Yes 2. No

If yes, how much and when: _____

19. **Where did the baby sleep last night? (circle the best answer)**

a. Crib or bassinette in his/her own room?
b. Crib or bassinette in your room?
c. In your bed?
d. A combination of a and c?
e. A combination of b and c?

Other (please describe) _____

Appendix F

Edinburgh Depression Scale

Edinburgh Postnatal Depression Scale[1] (EPDS)

Name: _____ Address: _____

Your Date of Birth: _____ _____

Baby's Date of Birth: _____ Phone: _____

As you are pregnant or have recently had a baby, we would like to know how you are feeling. Please check the answer that comes closest to how you have felt **IN THE PAST 7 DAYS**, not just how you feel today.

Here is an example, already completed.

I have felt happy:
- ☐ Yes, all the time
- ☒ Yes, most of the time — This would mean: "I have felt happy most of the time" during the past week.
- ☐ No, not very often — Please complete the other questions in the same way.
- ☐ No, not at all

In the past 7 days:

1. I have been able to laugh and see the funny side of things
   - ☐ As much as I always could
   - ☐ Not quite so much now
   - ☐ Definitely not so much now
   - ☐ Not at all

2. I have looked forward with enjoyment to things
   - ☐ As much as I ever did
   - ☐ Rather less than I used to
   - ☐ Definitely less than I used to
   - ☐ Hardly at all

*3. I have blamed myself unnecessarily when things went wrong
   - ☐ Yes, most of the time
   - ☐ Yes, some of the time
   - ☐ Not very often
   - ☐ No, never

4. I have been anxious or worried for no good reason
   - ☐ No, not at all
   - ☐ Hardly ever
   - ☐ Yes, sometimes
   - ☐ Yes, very often

*5 I have felt scared or panicky for no very good reason
   - ☐ Yes, quite a lot
   - ☐ Yes, sometimes
   - ☐ No, not much
   - ☐ No, not at all

*6. Things have been getting on top of me
   - ☐ Yes, most of the time I haven't been able to cope at all
   - ☐ Yes, sometimes I haven't been coping as well as usual
   - ☐ No, most of the time I have coped quite well
   - ☐ No, I have been coping as well as ever

*7 I have been so unhappy that I have had difficulty sleeping
   - ☐ Yes, most of the time
   - ☐ Yes, sometimes
   - ☐ Not very often
   - ☐ No, not at all

*8 I have felt sad or miserable
   - ☐ Yes, most of the time
   - ☐ Yes, quite often
   - ☐ Not very often
   - ☐ No, not at all

*9 I have been so unhappy that I have been crying
   - ☐ Yes, most of the time
   - ☐ Yes, quite often
   - ☐ Only occasionally
   - ☐ No, never

*10 The thought of harming myself has occurred to me
   - ☐ Yes, quite often
   - ☐ Sometimes
   - ☐ Hardly ever
   - ☐ Never

Administered/Reviewed by _____ Date _____

[1]Source: Cox, J.L., Holden, J.M., and Sagovsky, R. 1987. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry* 150:782-786 .

[2]Source: K. L. Wisner, B. L. Parry, C. M. Piontek, Postpartum Depression N Engl J Med vol. 347, No 3, July 18, 2002, 194-199

Edinburgh Postnatal Depression Scale[1] (EPDS)

Postpartum depression is the most common complication of childbearing.[2] The 10-question Edinburgh Postnatal Depression Scale (EPDS) is a valuable and efficient way of identifying patients at risk for "perinatal" depression. The EPDS is easy to administer and has proven to be an effective screening tool.

Mothers who score above 13 are likely to be suffering from a depressive illness of varying severity. The EPDS score should not override clinical judgment. A careful clinical assessment should be carried out to confirm the diagnosis. The scale indicates how the mother has felt ***during the previous week***. In doubtful cases it may be useful to repeat the tool after 2 weeks. The scale will not detect mothers with anxiety neuroses, phobias or personality disorders.

Women with postpartum depression need not feel alone. They may find useful information on the web sites of the National Women's Health Information Center <www.4women.gov> and from groups such as Postpartum Support International <www.chss.iup.edu/postpartum> and Depression after Delivery <www.depressionafterdelivery.com>.

SCORING

QUESTIONS 1, 2, & 4 (without an *)
Are scored 0, 1, 2 or 3 with top box scored as 0 and the bottom box scored as 3.

QUESTIONS 3, 5-10 (marked with an *)
Are reverse scored, with the top box scored as a 3 and the bottom box scored as 0.

Maximum score: 30
Possible Depression: 10 or greater
Always look at item 10 (suicidal thoughts)

Instructions for using the Edinburgh Postnatal Depression Scale:

1. The mother is asked to check the response that comes closest to how she has been feeling in the previous 7 days.
2. All the items must be completed.
3. Care should be taken to avoid the possibility of the mother discussing her answers with others. (Answers come from the mother or pregnant woman.)
4. The mother should complete the scale herself, unless she has limited English or has difficulty with reading.

[1]Source: Cox, J.L., Holden, J.M., and Sagovsky, R. 1987. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry* 150:782-786.

[2]Source: K. L. Wisner, B. L. Parry, C. M. Piontek, Postpartum Depression N Engl J Med vol. 347, No 3, July 18, 2002, 194-199

Appendix G

Demographic Information Sheet

ABOUT YOU: Part 1, to be filled out after consent to participate.

2. Age_____ ID#_____

3. Marital Status (please check one):
   ___ Married ___ Living with partner ___ Single/never married
   ___ Separated ___ Divorced ___ Widowed

4. Race/Ethnicity (please check one):
   ___ African American ___ Hispanic ___ Native American
   ___ Asian/Pacific Islander ___ Caucasian ___ Alaska Native
   ___ Other (please indicate) _____

5. Please indicate highest level of education completed:
   ___ Junior High ___ High School ___ Junior College
   ___ College ___ Graduate School

6. Please give the range of yearly income in your household:
   ___ Less than $15,000 ___ $45,001-$60,000
   ___ $15,001-$30,000 ___ $60,001-$75,000
   ___ $30,001-$45,000 ___ $75,001-$90,000
   ___ above $90,000

7. Is this your first child? ____ Yes ____ No

8. What was your pre pregnancy weight _____ and height _____

9. Has anyone ever told you that you have a sleep disorder (restless leg syndrome or sleep apnea for example)? _____
   _____

10. Do you have a history of depression? ___ Yes ___ No
    a. One time _____
    b. Repeated times_____

11. Have you ever taken medication for depression? ___ Yes ___ No

12. Have you ever been treated for mood disorder?
    ___ Anxiety ____Manic/depression ___ PMS ___Other

12. Do you have any chronic illnesses? _____ Yes _____ No
    If yes, please identify
_____

13. Do you exercise on a regular basis? _____ Yes _____ No
If yes, what exercise do you do?

_____

_____

About You: Part 2, complete after delivery or at the 2-3 week phone call:

14. How much did your baby weigh? _____

15. How long was your labor? _____

16. Did you have a vaginal or cesarean birth? _____

17. How are you feeding your baby? (circle)
___ Only Breast milk ___ Exclusively Bottle ___ Both

a. If breastfeeding, how many bottles a day does your baby receive? _____

b. If any bottles are they expressed milk or formula? _____

18. Is there another adult in the house? _____ Yes _____ No
    a. Do they help with the night time care of the baby?_____ Yes_____ No
    b. Are you the primary caregiver for the baby? ___ Yes _____ No

19. What medications are you currently taking or have you taken in the last two weeks?
_____

20. Where does your baby sleep?
    a. Crib or bassinette in his/her own room?
    b. Crib or bassinette in your room?
    c. In your bed?
    d. A combination of a and c?
    e. A combination of b and c?
    f. Other (please describe) _____

21. How many hours sleep do you average at night
    a. Before pregnancy _____
    b. During pregnancy _____
    c. Since having the baby _____

22. How many times do you usually get up during the night?
    a. Before pregnancy _____
    b. During pregnancy _____
    c. Since having the baby _____

Appendix H- Training for Sleep Study application

1. How to attach leads
2. How to set up sleep study

How to Attach Leads (outline from the PowerPoint)

Skull Landmarks

Nasion – indentation between the forehead and the nose found by facing the patient and feeling for the small dip at the bridge of the nose.

Inion – ridge at the back of the head found by running your finger up the back of the head where you will feel a depression with the ridge of the protruding inion just above it.
Preauricular Points – indentations just above the small piece of cartilage at the opening of the ear canal which can be best found by placing your finger over this cartilage and having the patient open and close their mouth.

Lets Get To It
Make a horizontal mark at each of the four landmarks (nasion, inion, both preauricular points).

Measure from nasion to inion.

Remember all marks made should be vertical to your tape measure unless otherwise instructed.

Front to Back
Measure from nasion to inion

Up 10% from nasion for level of Fp's

Up 50% from nasion for level of CZ

In back up 10% from inion for level of O's

Mark placement of FpZ using middle of nose as a guide

Side to Side
Measure from preauricular to preauricular

Up 10% from preauricular for the level of T3

From T3 up 20% for placement of C's.

From C3 up 20% for the placement of CZ

Do Both Sides

On second side the last up 20% is a double check for CZ

Circumference

C3 / C4 Location

Measure from Fp1 to O1 going through the level of C's

50% is the placement of C3

Repeat on the right side for the placement of C4

M1 and M2

Placed on the mastoid bone behind each ear.

Find the boniest flat area, usually between the crease of the earlobe and where the hairline begins.

Electrooculogram (EOG)

E1 and E2

E1–M2	1 cm below the left outer canthus	(LOC)
E2-M1	1 cm above the right outer canthus	(ROC)

Electomyogram (EMG)

Three electrodes should be placed to record chin EMG.

a. 1 cm above the inferior edge of the mandible on the mentalis muscle.
b. 2 cm below the inferior edge of the mandible and 2 cm to the right of midline on the submentalis muscle.
c. 2 cm below the inferior edge of the mandible and 2 cm to the left of the midline on the submentalis muscle.

Routinely record from either of the electrodes below the mandible referred to the electrode above the mandible. The unused inferior electrode is a backup electrode if one of the primary electrodes fails.

Prepare the Electrode Sites

To ensure a quality recording, electrodes must have a low impedance level.
The top layer of dry dead skin needs to be removed to reduce the natural impedance of the skin.
To do this lightly abrade a small area where the electrode will be placed using a cotton tipped applicator with an abrasive skin preparation product.
Make Sure The Electrodes Are Clean and In Good Condition

Gold Cup Electrodes

These type of electrodes are used for all scalp, facial and leg sites.
Electrodes may be secured by tape, conductive paste, or with the use of collodion.

Impedance

A material's opposition to the flow of electric current; measured in ohms.

Acceptable Impedance Levels

EEG, Mastoid, EOG, ECG

≤ 5,000 ohms

It is important to know that if these levels are not obtainable – the impedance values of all electrodes should be balanced.

Prepping the site (or re-prepping) should never be taken to an extreme as to cause patient discomfort or skin injury (bruising or bleeding).

Factors That Influence The Quality Of The Recording

Patient Preparation

Patient Cooperation

Testing Environment

What You Can Control Is …

Well Prepared Electrodes

+

Well Prepped Site

+

Electrode Properly Secured

=

Low Impedance Values

Low Electrode Impedance Values

=

High Quality Recording

How to set up sleep study (outline from powerpoint)

Items Needed Before Initializing

Base Station

- Amplifier Unit with Battery Installed, and Compact Flash Card in Place
- Tether Cable
- Host Computer with Twin Software
- Hook Up Completed

- Initializing Steps

- Connect Electrodes to the Amplifier Unit
- Turn Amplifier Unit On
- Connect Amplifier Unit to Base Station via Tether Cable
- Configure Amplifier Unit using associated Twin Host Software
- Initiate the recording with Twin Recording Feature (AURA PSG RECORD Icon)
- Begin Recording Data
- Do Impedance Check After viewing, close the window.
- Do AC Calibration by clicking on the AC Cal icon on the toolbar– all amplifiers are functioning properly unless the values are highlighted in blue. After viewing these values – close the Amplifier Calibrate window.
- Do Bio-Calibrations (bio-cals)

- F4 Eyes Open for 30 seconds
- F5 Eyes Closed for 30 seconds
- F6 With Eyes Open and Holding Your Head Still: Look Left
- F7 Look Right
- F8 Look Up
- F9 Look Down
- F10 Blink Five Times
- F11 Grit Teeth

- Continue Recording on Host Computer
- Turn Amp Unit Off and Disconnect from Base Station
- Turn Amplifier Unit Back On to Begin Recording to the Compact Flash Card

- On Host Computer – Stop Recording & Close Window

- Before the Window Will Close – You Will Be Asked "Would you like to continue the same record on the next session?"

- CLICK ON NO

- Trouble Shooting

- No Signals

- Check That Amplifier Unit is Turned On
- Check Tethered Cable
- Check Reference Electrode
- Check Ground Electrode

- Poor Quality Signals

- Check Impedance Levels and Reapply or Change Out Involved Electrodes

- Check Ground and Reference Electrodes
- Electrical Interference

- Check For Anything That Can Be Unplugged in the Subject's Bedroom and UNPLUG IT

- Check Ground and Reference Electrode